EVALUATION STUDY REPORT
FOR
ASEAN ROCK SALT-SODA ASH PROJECT
IN
THE KINGDOM OF THAILAND

MARCH 1981

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to a request of the Government of the Kingdom of Thailand, the Government of Japan decided to make an evaluation study on the Rock Salt-Soda Ash Project in Thailand which will be developed as one of the ASEAN Industrial Projects, based on the "Report on the Feasibility of a Rock Salt-Soda Ash Project in Thailand", prepared by SNC Inc., of Canada. The Government of Japan commissioned the Japan International Cooperation Agency (JICA) with the study.

Prior to conducting this evaluation study, first stage survey on the Rock Salt-Soda Ash Project, limited to the analysis of the rock salt deposit, was carried out by JICA in July, 1979.

Thereafter, the evaluation study was conducted from September, 1981, based on the results of the first stage survey.

As a result of the study, a draft final report was prepared in February, 1981, and after a series of discussions among expert groups both in Japan and in Thailand, it has been finalized into the present report.

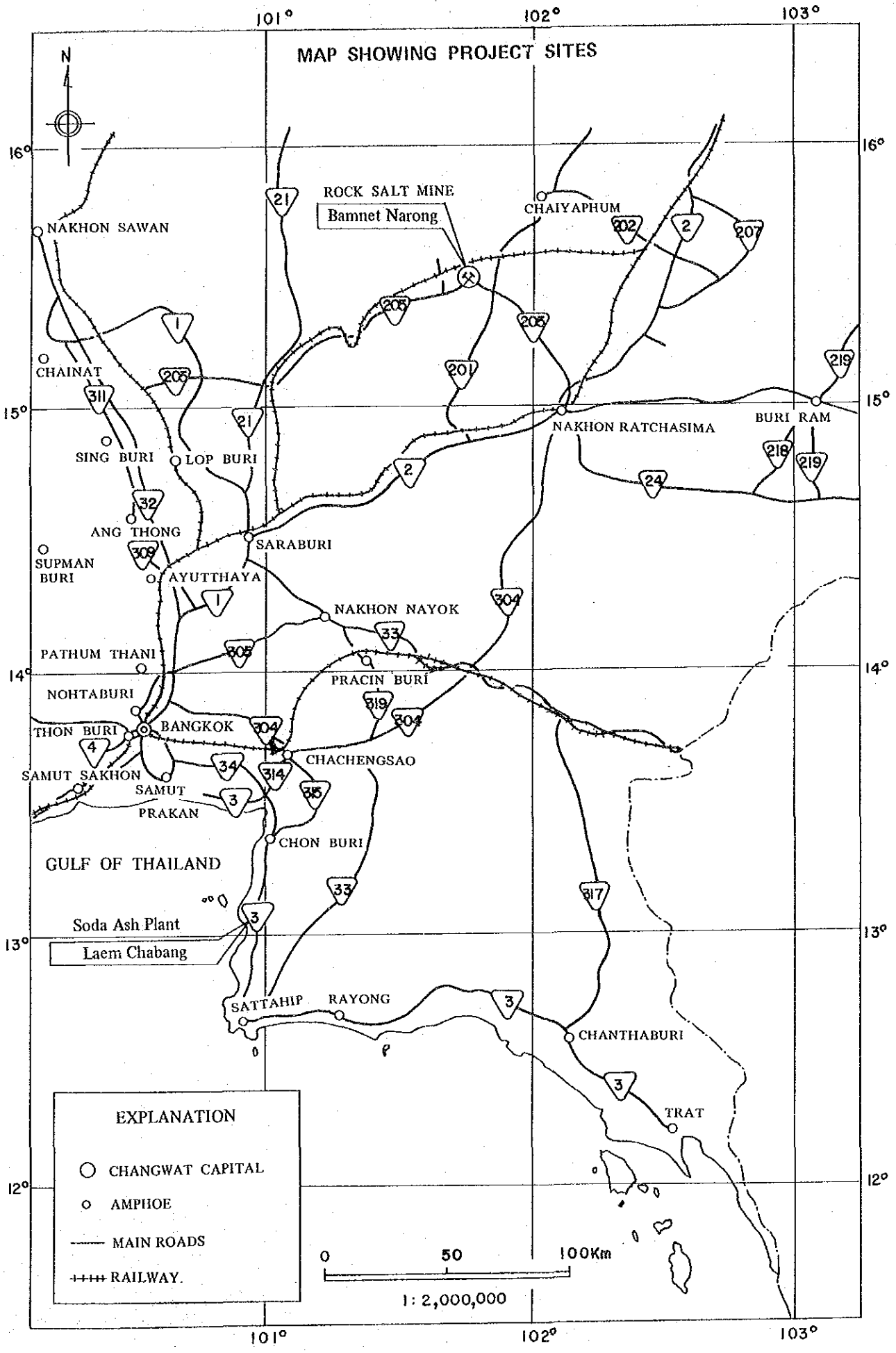
I hope that this report will prove to be useful for the development of the Project, thereby contributing to ASEAN cooperation, as well as promoting friendly and cooperative relations between the ASEAN member states and Japan.

I wish to express my deep appreciation to the officials concerned of the Government of Thailand for their close cooperation extended to the study team.

March, 1981

Keisuke Arita

Keisuke Arita
President
Japan International Cooperation Agency


MAP SHOWING PROJECT SITES
N
101°
102°
103°
16°
15°
14°
13°
12°
ROCK SALT MINE
Bamnet Narong
NAKHON SAWAN
CHAIYAPHUM
CHAINAT
SING BURI
LOP BURI
NAKHON RATCHASIMA
BURI RAM
ANG THONG
SARABURI
SUPMAN BURI
AYUTTHAYA
NAKHON NAYOK
PATHUM THANI
PRACIN BURI
NOHTABURI
THON BURI
BANGKOK
CHACHENGSAO
SAMUT SAKHON
SAMUT PRAKAN
CHON BURI
GULF OF THAILAND
Soda Ash Plant
Laem Chabang
SATTAHIP
RAYONG
CHANTHABURI
TRAT
EXPLANATION
CHANGWAT CAPITAL
AMPHOE
MAIN ROADS
RAILWAY.
0
50
100Km
1: 2,000,000

ABBREVIATIONS ETC.

General

GOT	Government of Thailand
C & F	Cost & Freight
CIF	Cost, Insurance & Freight
FOB	Free on Board
IRR	Internal Rate of Return
B	Baht
MSL	Mean Sea Level

Exchange Rate . US$1 = B20.5

Organizations

EGAT	Energy Generation Authority of Thailand
IEAT	Industrial Estate Authority of Thailand
NEB	National Environment Board
PAT	Port Authority of Thailand
PEA	Provincial Electricity Authority
PTT	Petroleum Authority of Thailand
RSR	Royal State Railway

Units

KVA	Kilovolt-ampere
KW	Kilowatt
KWH	Kilowatt-hour
MW	Megawatt (Million Watt)
MMBTU	Million BTU
MSCFD	Million SCF per Day
MSCF	Thousand SCF
QUEN	1,500 kg
RAI	0.16 ha
SCF	Standard Cubic Feet, 1SCF = 0.0283 Nm^3
SCFD	Standard Cubic Feet per Day
M/T, t	Metric Ton

Products

AC	Ammonium Chloride
K	Potash
MSG	Monosodium Glutamate
N	Nitrogen
P	Phosphate

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SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

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I. OUTLINE DESCRIPTION OF THE PROJECT

1) Rock salt mine

(a) Region where rock salt is to be mined

Following the original plan of the Thai Government, rock salt in deposits in the Bamnet Narong area of Northeastern Thailand is to be mined. It is proposed that mining be done in Halite-A of S-Area.

(b) Location of rock salt mine

Bamnet Narong (about 225 km northeast of Bangkok).

(c) Scale of mine production

Although the plan of the Thai Government calls for an initial level of mine production of 1.6 million t/y which is to be expanded later to 2.5 million t/y, on the basis of its study, the Japanese Evaluation Study Team (the Study Team) anticipates that it will be difficult to sustain a marketing effort consonant with that scale of output. Consequently, in accordance with the outlook estimated by the Study Team of the marketing of rock salt, the Team proposes a plan for the following smaller scale:

1.2 million t/y: Assuming (a) 2,000 t/d produced by each 8-hour shift, and (b) two shifts and 300 days of operation a year.

It is possible, moreover, to produce up to 1.8 million t/y by means of three-shift operation, which requires no additional installations in the event that such a production scale is realized.

(d) Mining method

The room and pillar method is to be used. A belt conveyor along the inclined shaft is to be used to transport the mined rock salt to the surface of the ground.

(e) Utilities

Electric power: To be supplied from the EGAT system, requiring construction of a 60 km transmission line.

Water: To be supplied by means of a pipeline from the Amphoe Bamnet Narong swamp about 8 km from the mine.

2) Soda ash plant

(a) Location of plant site

As has been proposed by the Thai Government, the plant is to be in the Laem Chabang district.

(b) Soda ash production process

As a result of technical and economic comparison of the Solvay Process, the Partial AC Process, and the Full AC Process, it is proposed that the Full AC Process be employed.

(c) Design capacity

Whereas the Thai Government had anticipated that the initial production capacity would be 400,000 t/y and that it would later be increased to 500,000 t/y, when the Full AC Process is employed, the marketability of ammonium chloride becomes the limiting factor and in view of that the following design capacity is proposed:

Soda ash: 400,000 t/y
Byproduct ammonium chloride: 400,000 t/y

(d) Required materials

(i) Rock salt: A rock salt storage facility is to be established in the site of soda ash plant and is to be used for shipment of rock salt to be exported as well as storage for supply to the plant. Rock salt is to be transported from the mine to the storage facility by railway wagon, and transport of the rock salt from the facility to the soda ash plant is to be by belt conveyor.

(ii) Limestone substitute: In consideration of project economics, and waste disposal problems, limestone is not to be used and substitutes are proposed:

- Carbon dioxide which is separated from natural gas at the PTT natural gas processing plant in the Rayong district can be collected rather than discharged, and conveyed to the soda ash plant by a newly-constructed pipeline. However, in the event that the fertilizer complex now being planned by the Thai Government is constructed on a site adjacent to the present project, excess carbon dioxide produced in the ammonia plant of the complex can be supplied by pipeline from that plant to the soda ash plant, to substitute for the carbon dioxide supplied from the PTT gas processing plant.

- Quicklime can be purchased from existing carbide producers in Thailand
- Soda ash produced at the soda ash plant of this project is to be used.

(iii) Ammonia: Use of imports is anticipated, but if the fertilizer complex is constructed adjacent to the soda ash plant site, it can be used as a source of ammonia.

(e) Utilities

(i) Electric power: To be supplied by the Provincial Electricity Authority (PEA) as a public service, to the transformer station within the plant site.

(ii) Water: To be supplied to the Laem Chabang area by means of a pipeline laid by the Industry Estate Authority of Thailand (IEAT) from a reservoir.

(iii) Fuel: Use of heavy oil is planned but if a natural gas branch pipeline to the Laem Chabang area is contructed, natural gas is to be used.

3) Infrastructure

(a) Railroad

Transport of rock salt is to be by railroad. This requires the following.

– Rail spur for the mine (5.7 km distance)
– Rail spur for the soda ash plant (3.2 km distance)
– Hopper cars (138)*,**
– Marshaling locomotives (3)*,**

(Note) * Assuming 1.2 million t/y production
** Assuming that hopper cars and marshaling locomotives will be procured by the RSR at its cost.

(b) Assuming that the Laem Chabang Deep Sea Port, which the Thai Government has decided to construct, is completed and ready for use by the time needed for implementation of this Project, the facilities of that port are to be used. The costs of bulk handling facilities and conveyors for transport of rock salt and soda ash are to be borne by the present project. (In the event that construction of Laem Chabang Deep Sea Port is delayed, a temporary jetty is to be constructed at the coast at Laem Chabang, and barges will be used for transport of the rock salt and soda ash to ships, or, temporarily, shipments may be made via Sattahip. In these cases, however, the additional shipping costs would greatly reduce the product's competitiveness.)

4) Implementation schedule

The start of operation of the plant and mine is assumed to be in mid-1985.

5) Capital requirements (excluding interest during construction) in which the costs of constructing rail spurs are included are as follows.

(million US Dollars)

	Foreign currency portion	Local currency portion	Total
– Rock salt mine	23.4	30.3	53.7
– Soda ash plant	246.9	104.1	351.0
Total	270.3	134.4	404.7

(Note) The above excludes interest during construction but includes pre-operation costs and initial working capital. The cost of rail spurs are included, but other required rail transport facilities are excluded from the scope of this Project.

II. MARKET STUDY

1) Soda ash

1-1) Outlook for soda ash demand, and projected volume of soda ash sales of this Project

1. The ASEAN nations have reached an agreement guaranteeing their purchases of soda ash from this Project. The sales volume as projected by the Thai Government is shown in Table 1.

Table 1. PROJECTED SALES OF SODA ASH TO THE ASEAN NATIONS (Forecast by the Thai Government)

(Unit: 1,000 t)

	1980	1985	1990
Thailand	81	127	205
Malaysia	34	54	86
Singapore	18	26	36
Indonesia	68	110	176
Philippines	104	143	202
ASEAN Total	305	460	705

2. On the basis of the above envisioned arrangements, supply of soda ash from the Project would satisfy the majority of ASEAN nations' requirements. Demand for soda ash in the ASEAN nations, as forecast by the Study Team, is given in Table 2.

Table 2. ESTIMATED DEMAND FOR SODA ASH IN THE ASEAN REGION (Forecast by the Study Team)

(Unit: 1,000 t)

	1985	1990	1995
Thailand	119.6	175.3	223.3
Malaysia	53.5	74.2	100.3
Singapore	22.7	26.3	30.1
Indonesia	124.6	170.1	223.3
Philippines	109.1	146.7	193.3
ASEAN Total	429.5	592.6	770.3

3. However, the following conditions would be taken into consideration: (a) the Southeast Asian market's historically having been the major market for natural ash from Kenya, and having been a spot market for East European and Korean products, and (b) particularly that Kenya is planning on doubling production capacity of natural ash. In order to secure markets for the soda ash of this Project, it seems to be essential that preferential arrangements within the ASEAN market are made for soda ash under the Preferential Trading Arrangements. Nevertheless, since it is not known yet as to what arrangements will be made, in view of these conditions, it is ash, but due to the discovery of natural ash in the United States and produced by this Project is to be as shown below, in Table 3.

Table 3. MARKETABLE QUANTITY OF SODA ASH IN THE ASEAN REGION (Forecast by the Study Team)

(Unit: 1,000 t)

	1985	1990	1995
Thailand	120	175	223
Malaysia	43	60	80
Singapore	16	18	21
Indonesia	93	128	168
Philippines	96	129	170
ASEAN Total	368	510	662

4. As is evident from Table 3, the forecast made by the Study Team of the marketable quantity of soda ash from the Project is lower than that which had been forecast by the Thai Government.

1-2) Soda ash market price

1. The major source of soda ash supply in the past has been synthetic soda ash, but due to the discovery of natural ash in the United States and Kenya the relative cost competitiveness of the synthetic product has declined, and natural ash has come to dominate soda ash trade. In the ASEAN region, reflecting this worldwide situation, the status of Japan which had been a major exporter to the ASEAN markets has steadily experienced a decline and, simultaneously, the status of Kenya products in the ASEAN market gained in importance. Moreover, it is expected that

in the future American exports to the ASEAN region will also increase.

3. In the past Kenya maintained its market share on the strength of the low price of its natural ash, but recently has changed its approach and whereas in the past the Kenya product had been lower in price than that of the United States, recently it has tended to follow the American product in terms of price. It is expected that this tendency will continue in the future. Therefore it may be assumed that in the future the market price will be determined by the American product's price. The outlook is that in the United States from about 1985 there will be a shortfall in supply of soda ash, and at such a time it is to be expected that price formation will take place within the entire soda industry, including caustic soda. In view of this it is expected that the price of American natural ash will increase. On the other hand, Kenya has embarked on a program intended to double its supply capacity and because Kenya will be faced by a tendency for there to be an over-supply, it is likely that Kenya will export ash at prices somewhat lower than those of the American product.

4. On the basis of consideration of the conditions as described above, the CIF prices for soda ash in the ASEAN nations are as in Table 4 below.

Table 4. PROJECTED SALES PRICE FOR SODA ASH IN THE ASEAN NATIONS (1985)

(Unit: US$/t)

	CIF price in country of destination
Thailand	225
Malaysia	229
Singapore	230
Indonesia	229
Philippines	225

2) Rock salt

2-1) Outlook for rock salt demand, and marketable rock salt quantity from this Project

1. Although the Thai Government sought to obtain purchase guarantees from other ASEAN countries for rock salt, because it has not proved possible to obtain such consent, it has become necessary for the entity implementing this Project to undertake the marketing of surplus rock salt (i.e., rock salt available after requirements for production of soda ash in the plant are met) under free market conditions within Thailand, and the exporting of it.

2. According to the Thai Government plan, as shown in Table 5, a considerable quantity of exports to the ASEAN nations is anticipated. This marketing plan was formulated on the basis of the demand projections made by SNC, the Canadian firm retained as the consultant by the Thai Government, at the stage of the feasibility study for this Project. Because the SNC study did not take into account the supply of solar salt in each country, its report contains inflated figures for rock salt demand in those countries.

Table 5. ANTICIPATED QUANTITY OF ROCK SALT MARKETED IN THE ASEAN REGION (Thai Government Forecast)

(Unit: 1,000 t)

	1980	1985	1990
Thailand	149	216	362
Malaysia	82	120	206
Singapore	37	46	65
Indonesia	220	354	606
Philippines	115	161	226
ASEAN Total	603	897	1,465

(Note) Rock salt supplied to the soda ash plant is excluded from the above.

3. In actuality, production of solar salt is being undertaken in Thailand, Indonesia and the Philippines, and with the exception of a portion of industrial salt each country has satisfied its demand by means of this solar salt. In the case of Thailand in particular not only are domestic requirements being met by solar salt but the country is exporting solar salt to Malaysia and Singapore besides, and this situation is not expected to

change in the near future. Meanwhile, faced with increased demand for industrial salt, Indonesia and the Philippines are progressing with plans for significant increases in domestic production capacity of industrial salt, and moving toward positions wherein they will be self-sufficient with regard to salt, including industrial salt. Because the quality of Thai-produced solar salt is low, it is possible that rock salt can be used as industrial salt in that country. But in view of the conditions as described above, the only countries in the ASEAN region other than Thailand which could use Thai rock salt, and become potential export markets for rock salt thereby, are Malaysia and Singapore. But even in this case, as is described below, because of a problem concerning the quality of the Thai rock salt, as well as competition with Australian salt, optimism over the prospects for exportation of rock salt are not justified. The quantity of rock salt which may be considered marketable in the ASEAN region, in light of the foregoing conditions, is as shown in Table 6.

Table 6. ANTICIPATED QUANTITY OF ROCK SALT MARKETED IN THE ASEAN REGION (Study Team Forecast)

(Unit: 1,000 t)

	1985	1990	1995
Thailand	81	178	245
Malaysia	147	199	217
Singapore	8	8	9
Indonesia	—	—	—
Philippines	—	—	—
ASEAN Total	236	385	471

(Note) Rock salt supplied to the soda ash plant is excluded from the above.

4. In addition, about 100,000 t/y could be exported to outside the ASEAN region (mainly Taiwan) by using 15,000 to 20,000 DWT class vessels. If 60,000 DWT class vessels can be used, the exports to non-ASEAN would be increased. Moreover, with a soda ash production level of 400,000 t/y, the quantity of rock salt supplied to the soda ash plant would be about 200,000 t in 1985 (70% utilization of capacity, and half-year operation), and about 560,000 t in 1990 (100% utilization of capacity). With the

inclusion of these quantities, the total anticipated quantity of marketable rock salt, as shown in Table 7, is much lower than the level which had been expected by the Thai Government.

Table 7. OUTLOOK FOR MARKETABLE ROCK SALT FOR THIS PROJECT

(Unit: 1,000 t)

	1985	1990	1995
1) Supply to soda ash plant	198*	562	562
2) Domestic sales in Thailand	81	178	245
3) Exports to ASEAN region	155	207	226
Malaysia	(147)	(199)	(217)
Singapore	(8)	(8)	(9)
4) Exports to outside ASEAN region	100	100	100
TOTAL	534	1047	1133

(Note) *Assuming the soda ash plant starts operation in July, 1985.

2-2) Marketability of Thai rock salt

In view of the sodium chloride content of the rock salt to be mined in this Project, it has a quality comparable to other sources of salt being used as industrial salt. The Thai rock salt appears to have slightly higher contents of the insoluble matter (I.M.) particularly the sulfates, although this is still a provisional view, assumed on the basis of a limited number of samples available for analysis. Because users which might use this as industrial salt would have to incur additional costs of purification of the salt, it would be necessary to lower the sales price to them to some extent. Nevertheless, this salt is of a quality which lies within the range of usability as industrial salt and it is judged that it is marketable given the stipulation that the price is discounted as described below.

2-3) Rock salt sales price

1. Australia and Mexico are the two major exporting countries engaged in world salt trade. Japan is the world's largest importer, and Australia and Mexico compete for share in that market. Price formation for salt is strongly influenced by the cost of ocean freight. Both Australia and

Mexico have sought to reduce unit freight costs through such measures as utilizing large carriers (60,000 DWT class) and improving loading capacity. Both countries' export price (FOB) to other countries is determined on the basis of the FOB price for sale to Japan.

2. Australia is the major exporter to the Southeast Asian market, and exports from Thailand would have to compete with Australian salt. The CIF price to each country would be determined by adding to the Australian FOB price the cost of ocean freight which is determined in turn by the size of the vessel used, and it is necessary for any exports from Thailand to be competitive with the CIF price for Australian salt in importer-country delivered prices.

3. Using these assumptions, the CIF price for each country, as the 1985 price, and the FOB price obtained by subtraction of the freight cost from Thailand, are given in Table 8 below.

Table 8. EXPORT PRICE LEVEL FOR THAI ROCK SALT (1985)

(Unit: US$/t)

Destination	Destination country CIF price	Cost of transportation from Thailand	Thai FOB price
Malaysia	50	17	33
Singapore	41	15	26
Taiwan	34	15	19
S. Korea	34	19	15
Japan	34	19	15

(Note) Assuming the use of 15,000–20,000 DWT class or smaller vessels.

4. The above assumes that the quality of Thai export rock salt is equivalent to that of Australian product as already in the market. But in view of the slightly lower purity of Thai salt relative to the Australian products, as mentioned in 2-2-2, some discount in price is needed to compensate for the quality differential. It would also be necessary to consider additional

discounting as being necessary in order to become established in a new market. In view of these conditions, the projected Thai FOB prices for each importer country are as follows. It is noted that the ocean freight charges to Taiwan, S. Korea and Japan cited above were estimated on the assumptions that 15,000 to 20,000 DWT vessels are used, due to constraints in Thailand port facilities. If it is possible to use 60,000 DWT class vessels, the freight could be reduced to US$17/t, so that the Thai FOB price could be increased to US$16/t, even taking a discount into account.

Table 9. SALES PRICE OF ROCK SALT PRODUCED BY THIS PROJECT (1985)

(Unit: US$/t)

Destination	Price
Thailand	30
Malaysia	29
Singapore	24
Non-ASEAN (Taiwan)	*17
Non-ASEAN (Others than Taiwan)	16

(Note) Assuming the use of 60,000 DWT class vessels.

3) Ammonium chloride

3-1) Outlook for ammonium chloride demand, and marketable ammonium chloride quantity from this project

1. Ammonium chloride is one form of nitrogen fertilizer and, accordingly, its marketability is largely dependent on the combination in each country of types of crops cultivated, soil characteristics, and fertilizer use patterns. In the ASEAN countries, other than Thailand, urea and ammonium sulphate are the most commonly used nitrogen fertilizers (in some countries extensive use is made of ammonium nitrate), so there is no outlook for exportation of ammonium chloride to these countries. The most commonly used fertilizer in Thailand has been compound fertilizer; as the source of nitrogen in its production, imported ammonium chloride has been used. Hence, if ammonium chloride is produced by this project, it can substitute for those imports. It is thought that production of com-

pound fertilizer, as well as facilities for its production, will increase in the future in keeping with the growth of demand. Moreover, there is some use of ammonium chloride as straight fertilizer.

2. Whereas ammonium chloride or ammonium-chloride-containing compound fertilizer has been used for paddy rice cultivation in the past, it is expected that this trend will continue. In view of this and relevant conditions, the outlook for the quantity of ammonium chloride marketable in the domestic Thai market is as shown in Table 10.

Table 10. OUTLOOK FOR MARKETABLE AMMONIUM CHLORIDE IN THAILAND
(Study Team Forecast)

(Unit: 1,000 t)

1985	1990	1995
285	373	433

3. Outside of the ASEAN region, India and China have been the major nations which have made use of imports of ammonium chloride from Japan. If the product of this Project is cost-competitive, it is expected that exports on the order of 40–50,000 tons will be possible.

3-2) Ammonium chloride sales price

The market price of ammonium chloride is determined in relation to the prices of other nitrogen fertilizers.

The price in 1985, taking into consideration this linkage, is forecast to be as follows.

- Price in the domestic Thai market US$150/t
- Export price (FOB) US$120/t

III. STUDY OF TECHNICAL ASPECTS OF DEVELOPMENT PLANNING OF THE ROCK SALT MINE

1) Rock salt deposit

1-1) The Bamnet Narong rock salt deposit is located in the southwest portion of the Khorat Plateau in northeastern Thailand, at approximately 15°28′ northern latitude and 101°24′ eastern longitude. The deposit is in strate laying below 60–80 m from the surface, and is 100–280 m thick (see Figure 1).

1-2) There are two strata of rock salt in the deposit, but the higher-quality Halite-A stratum (S-Area) is of primary concern. The mining level is at the elevation of 61 m from sea level, at about 140 m under the surface of the ground. The recoverable reserves of salt within the selected zone are estimated to be 37 million tons and at the scale of production envisioned in this study (1.2 million tons/year) this quantity of reserves is adequate for 30 years operation, which is adequate over the life of this Project.

1-3) It must be noted, however, that the above selection is still in a preliminary stage from an engineering point of view, although it provides a basis sufficient for financial evaluation, and will require precise review in order to develop the final design which should be prepared for inviting contractors. For this end it is recommended that rock mechanic tests, soil tests and other relevant efforts be made by the Thai authorities in order to collect and analyze more data and information as required.

1-4) There are some analyses indicating that higher purity of rock salt exists in a deeper stratum. However, since these analyses provide limited information to determine whether such higher purity of rock salt is prevalent or not, the mining level cited above has been selected as the basis for the present study. It is recommended that further efforts be made by the Thai authorities with regard to the collection and analysis of additional samples.

2) Mining plan

2-1) The scale of mine production is taken to be 2,000 tons per single 8-hour shift. On the assumption that the mine is worked in two shifts and worked 300 days out of the year, if annual production level greater than that is required, production can be raised to 1.8 million tons by working in three

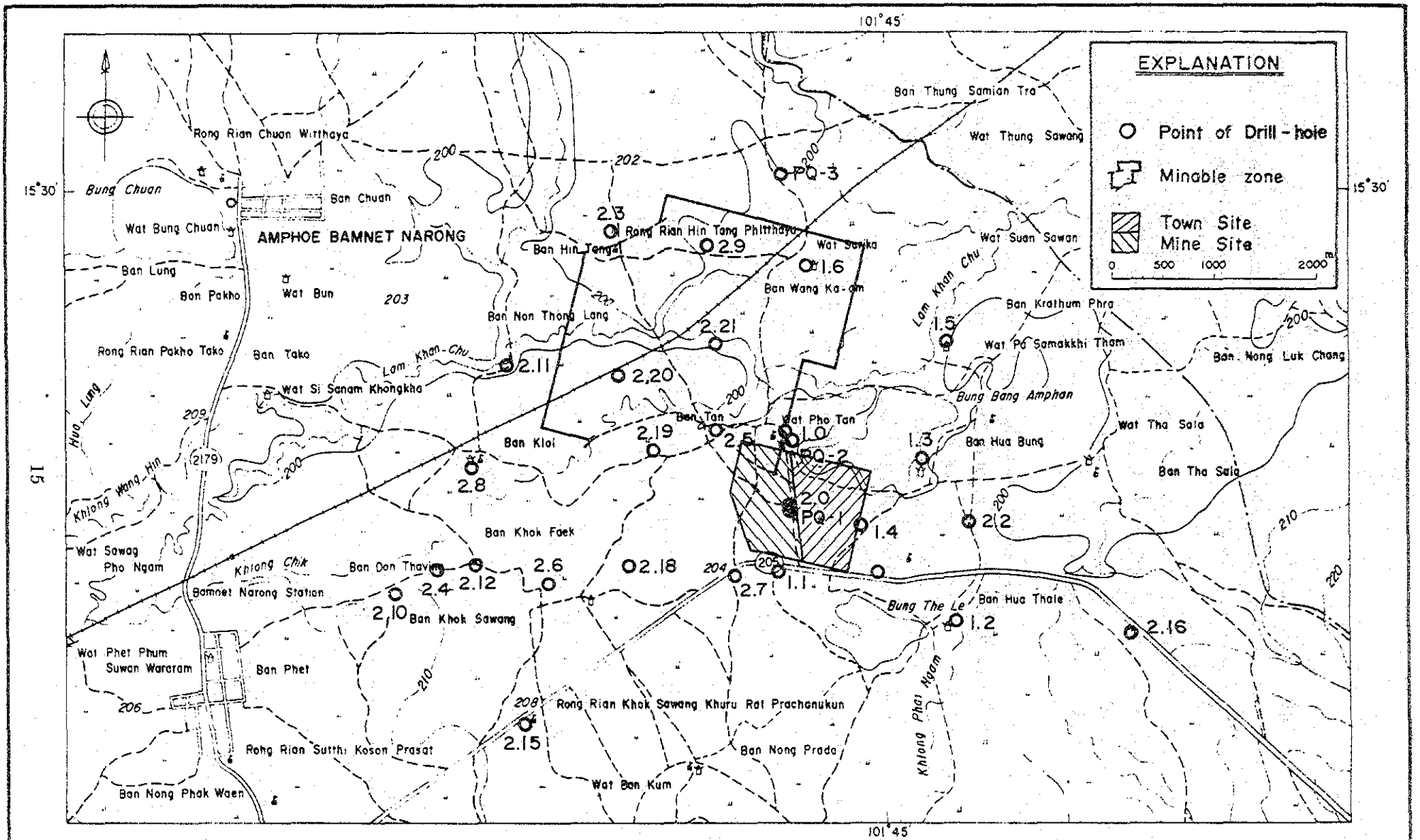


Fig. Ⅲ-1. Index Map of Bamnet Narong Area

shifts. In this case, the only additional investment required would be that of the cost of living quarters for the additional workers and there would be no need to expand or increase the major mining equipment and facilities.

2-2) The room and pillar method is to be employed, and considerations are to be given so as not to interfere with the railroad, fields and paddies, villages, etc. on the surface. Blasting is to be employed in order to minimize loose salt and also minimize investment cost.

2-3) Mechanized mining methods are to be used. Crushing and screening are to be performed within the mine, so as to prevent any environmental problems caused by noise and airborne salt particles. Salt which has been crushed and screened will be transported to outside the mine by a belt conveyor and charged to a bunker for loading of freight cars.

2-4) Supply of utilities required for the mine is to be as follows.

- Electric power — to be supplied from EGAT's system and hence to require a 60 km transmission line.
- Water — to be obtained from a swamp at Amphoe Bamnet Narong, at a distance of about 8 km from the site.

2-5) All of the facilities, equipment and structures for the mine, including those directly required for production, utilities and ancillary use (e.g., worker's housing quarters) are to be newly constructed and acquired. A rail spur is to be constructed for use in transporting products from the mine.

3) Implementation schedule and manpower plan

3-1) Construction of the mine and related facilities including utility facilities is to be accomplished in 3 years. Therefore, operation is assumed to begin in mid-1985.

3-2) For two shifts, about 200 employees including a Mine Manager will be required to operate the mine.

4) Consideration on prevention of environmental problems

In examining the design of mine facilities, mining method and excavation work as well as mine operation, full consideration has been given to the prevention of any environmental problems caused by the construction and operation of the rock salt mine.

IV. ROCK SALT TRANSPORTATION PLAN

1) Mode of transporting rock salt

In keeping with the Thai Government plan, the rock salt is to be transported from the mine to the soda ash plant by rail. The existing track from the Bamnet Narong area extends to Chachengsao by way of Bangkok. Although there is not at present any track between Chachengsao and Laem Chabang where the soda ash plant is to be constructed, the extension of the railway from Sattahip to Chachengsao has already been approved and because this construction will be completed by the end of 1983, the extension will be usable for transportation of rock salt (see Figure 2). Improvement of the existing line is needed in several places, but this as well as track doubling will be done by the Royal State Railway part of its work and hence funded by the RSR itself.

2) Transport facilities which are needed for sole use by this Project

The following rail transportation facilities are needed for sole use by this Project.

- Rail spur for the mine (5.7 km distance)
- Rail spur for the soda ash plant (3.2 km distance)
- Hopper cars (138)*,**
- Marshaling locomotives (3)* ,**

(Note) * Assuming 1.2 million t/y production.
** Assuming that hopper cars and marshaling locomotives will be procured by the RSR at its cost.

3) Rail freight charge

The competent Thai Government officials have not yet determined the rail freight charges to be applied to products of this Project, but the cost quoted by the Royal State Railway was US$8/t of rock salt transported from the mine to Laem Chabang. In view of this rate, it is quite likely that this amount of transportation costs would substantially increase the cost or rock salt so that not only export competitiveness of the rock salt but cost competitiveness of soda ash and ammonium chloride are adversely affected. The project economics can therefore benefit greatly if the Thai Government ministries and RSR officials concerned were able to agree on a preferential rate for the rock salt transport.

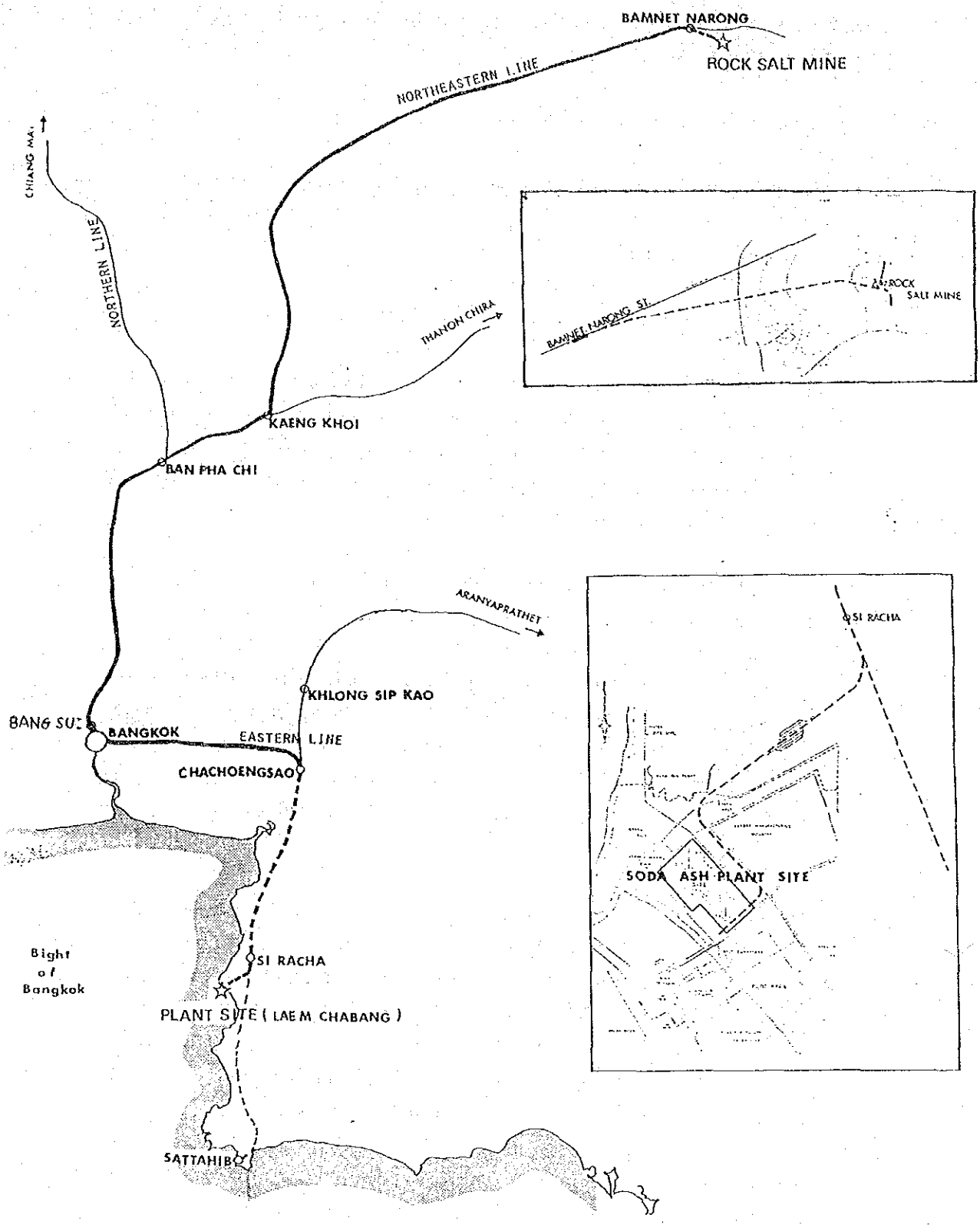


Figure 2 LOCATION MAP OF ROCK SALT MINE AND SODA ASH PLANT

V. STUDY OF TECHNICAL ASPECTS OF CONSTRUCTION PLANNING FOR THE SODA ASH PLANT

1) Production process and production capacity

1-1) There are three basic types of soda ash production process, namely:

- Solvay Process
- Full AC (Ammonium Chloride) Process
- Partial AC (Ammonium Chloride) Process

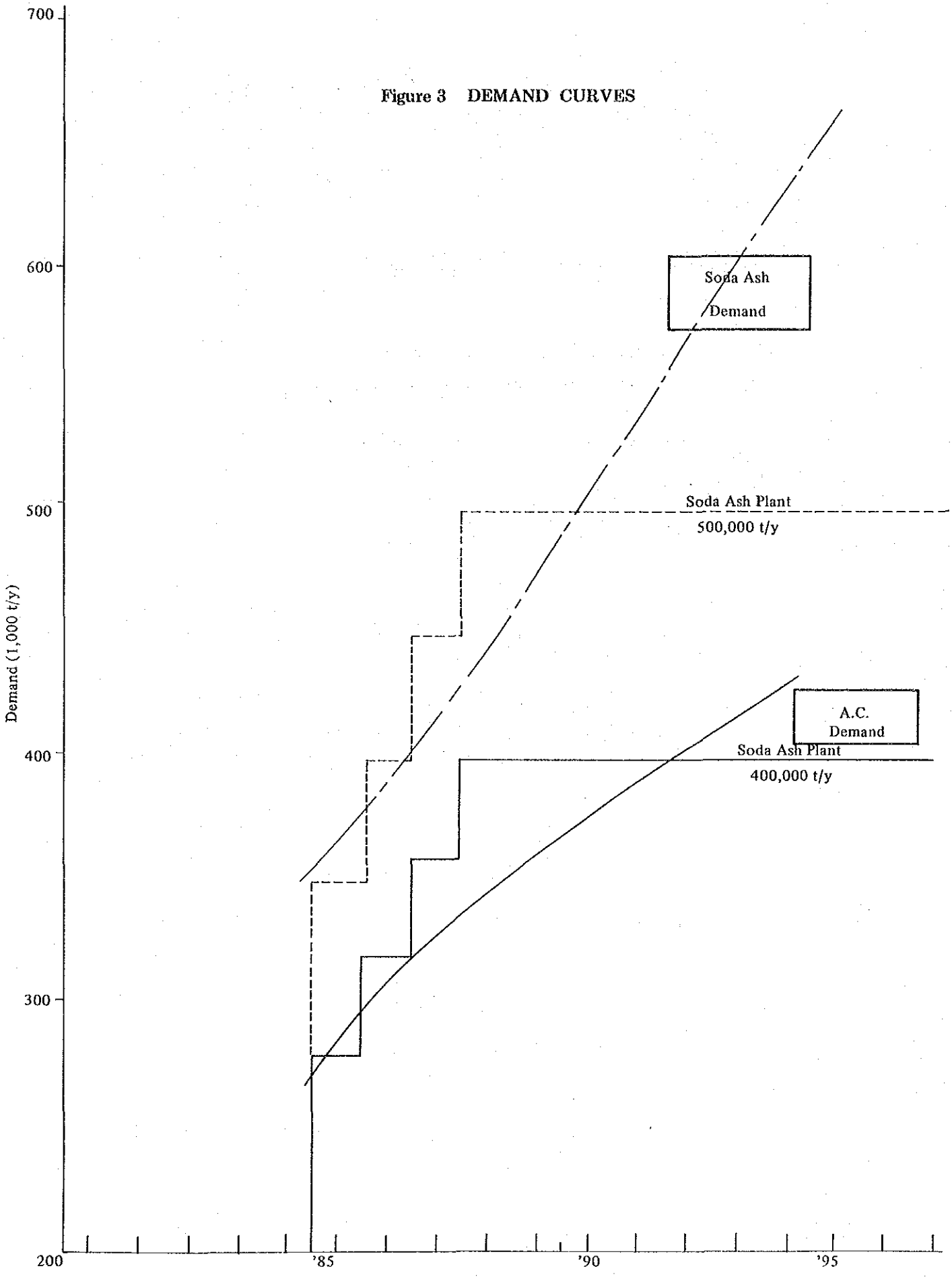
1-2) The Solvay Process uses salt and limestone as the major raw materials. The process has been widely used throughout the world since long ago, and yields calcium chloride in about the same quantity as the soda ash, in addition to which sodium bicarbonate, slaked lime, etc. are contained in the effluent and present a problem for treatment of the effluent.

1-3) The Full AC Process uses salt as the primary raw material, and ammonia and carbon dioxide gas as secondary materials. In addition to the soda ash, ammonium chloride (a nitrogen fertilizer) is produced in approximately equal quantity. The level of byproduct waste materials in the effluent of this process is low, and effluent treatment is not particularly difficult or costly; although the process thus is advantageous relative to the Solvay Process with regard to waste water treatment, the marketability of ammonium chloride, which is produced in large quantity, generally is a restraint on soda ash production scale.

1-4) The Partial AC Process is intermediate between the Solvay Process and the Full AC Process and is characterized by ability to regulate the level of production of ammonium chloride, so that such production is in keeping with the product's marketability. Nevertheless, the effluent from this process resembles that from the Solvay Process. Although the effluent volume is considerably lower than that of the Solvay Process, it is still necessary to consider the problem for treatment of the effluent before disposal.

1-5) Because the characteristics of the three types of process thus are different, production planning will be influenced by choice of process type. The Study Team considered the relative merits and demerits of each in conjunction with study of the market scale for both soda ash and ammonium chloride (see Figure 3).

Figure 3 DEMAND CURVES



	Process type	Soda ash production	Ammonium chloride production
A	Solvay	500,000 t/y	–
B	Partial AC	500,000 t/y	380,000 t/y
C	Full AC	400,000 t/y	400,000 t/y

The following criteria were used for selection of the scheme:

- Capital cost
- Production cost, and return on investment
- Waste treatment and disposal problems

1-6) The initial investment cost for the above three cases is:

Case A	US$ 315.45 million
Case B	US$ 421.72 million
Case C	US$ 348.76 million

(Note) These figures include pre-operation costs and initial working capital, but exclude interest during construction.

1-7) The production cost and internal rate of return (IRR; before tax) as calculated on the basis of the above initial investment cost, is as follows for each case. This calculation was made only for purposes of relative comparison.

	Case A	Case B		Case C	
	Soda ash	Soda ash	AC	Soda ash	AC
Production cost (1985 prices) (US$/T)[1)]	305.5	257.2	130.1	227.7	121.5
IRR (before tax)[2)]	(*)[3)]	2.92%		8.27%	

(Notes) 1)-1 Major input costs (1985 prices) are:

– Rock salt	US$17/t
– Limestone	US$10.5/t

– Cokes	US$210/t
– Ammonia	US$175/t
– Quicklime	US$28/t
– Caustic soda	US$420/t
– Power	US$0.066/KWH
– Water	US$0.108/$m^3$
– Fuel (Heavy Oil)	US$227/$m^3$
– Carbon dioxide	Zero value

1)-2 Including ROI 8%

2) Major assumptions taken for the computation of IRR are:

a) Project life: 12 years

b) Product sales price (1985)

– Soda ash, domestic market:	US$225/t
– Soda ash, exports (FOB):	US$202–210/t
– Ammonium chloride, domestic market:	US$150/t
– Ammonium chloride, exports (FOB):	US$120/t

c) Depreciation: 12-year straight-line depreciation

3) No IRR figure is indicated because total cash generated is lower than cash outlay.

1-8) As indicated in the comparison of capital cost in 1–6 above, the lowest cost is that of Case A, but as a result of the investigation in 1–7, Case C is found to be the most economically attractive. This is also the case for which treatment of effluent presents the least problem. In view of this, Case C is selected as the best choice and used as the basis for the present study by the Study Team.

Therefore:

– Production process:	Full AC Process
– Production scale:	soda ash, 400,000 t/y
	ammonium chloride, 400,000 t/y

are proposed for this Project. Relevant issues in connection with construction planning of the soda ash plant are discussed below, on the basis of this scheme.

2) Site conditions at the soda ash plant construction site

2-1) Prior to the present study it was proposed by the Thai Government that the soda ash plant be constructed in the Laem Chabang district. Therefore this study includes analysis of technical problems and site conditions related to the use of the proposed site. An assessment study of the environment following the guidelines of the National Environment Board, however, was not included in the work undertaken for the present evaluation study.

2-2) This district is located on the east shore of the Gulf of Thailand, and is about 100 km from Bangkok on the Route 3 highway.

2-3) The physiography of the site, which is flat, is suitable for construction of an industrial plant. Because borings at the site have not been made, information on the subsurface soil conditions is not available, but judging from existing data it is believed that no problems will be encountered if construction is undertaken at this site.

2-4) The site is near Route 3, and near the right-of-way of the Chachengsao-Sattahip railway extension. Therefore, the site is conveniently located with regard to transportation of rock salt to the plant and of products to market.

2-5) Conveyance of the carbon dioxide required for this Project may be accomplished by use of a pipeline. Water and power supply are to be provided by the Industry Estate Authority of Thailand (IEAT). Need exists to assure that the utility requirements can be met by the time that plant construction is completed. It is therefore of exceedingly high importance for the Ministry of Industry and the IEAT to closely coordinate their policies and programs related to this Project, and as long as such coordination is established for this Project, major problems are unlikely to occur.

2-6) It is necessary for the site to be adjacent to port facilities for use in receiving shipments of imported ammonia and in loading outgoing shipments of products from the soda ash plant as well as the mine. The Thai Cabinet has already approved plans for construction of a deep sea port at Laem Chabang,

and it is assumed here that the facilities of that port would be available for use in connection with the Project. If, however, this port construction project is delayed, adoption of alternative means, which is considered in this study as a possibility, would cause the shipment cost to be increased. It is therefore vital for this port construction project to be swiftly implemented so as to be in time for use in connection with the present Project, and thereby assure the cost competitiveness of its products.

2-7) As a result of the evaluation as summarized above, and on the assumption that the port is constructed and available for use, the proposed site is considered to be suitable for construction of the soda ash plant.

3) Raw material requirements, and utility requirements, of the soda ash plant

3-1) The principal raw material for this Project will be rock salt, mined as part of the Project itself, but with regard to the other materials, as a result of comparative study with due consideration given to economic matters as well as the processing and disposal of waste products, the following selection has been made.

1. Carbon dioxide: Rather than generate carbon dioxide by calcination of limestone, carbon dioxide contained in natural gas is to be used. Carbon dioxide separated from natural gas at the PTT gas processing plant in the Rayong district is to be recovered, and conveyed by pipeline to the site.

2. Quicklime: To be purchased from existing carbide producers in Thailand.

3. Caustic soda: It is planned that the soda ash produced at the sola ash plant of this Project is used.

3-2) Study was done of the possibility of importing the ammonia which will be required by the plant, but if the fertilizer complex which is now being planned is constructed adjacent to the soda ash site, ammonia can be obtained from that complex by a pipeline. In such a case, the carbon dioxide could also be provided by means of a pipeline from the fertilizer complex. If ammonia and carbon dioxide can be obtained from the fertilizer complex, the capital cost as well as operating cost will be reduced.

3-3) With regard to utilities, discussion of the supply of water and electric power is provided in an earlier part of this Summary, and reference should be made to the section. Regarding fuel, because there is no concrete plan at the present time for construction of a natural gas pipeline to Laem Chabang, it is planned to use heavy oil, but if it becomes possible to use natural gas, it should be burned as the plant's fuel.

4) Scope of facilities to be provided for the soda ash plant

4-1) On the basis of the conditions summarized above, the soda ash plant is to be constructed as described below.

1. Soda ash manufacturing process plant

2. Utilities facilities

- Power transformer and distribution
- Emergency power generator
- Water treatment facilities
- Cooling water system
- Boiler facilities
- Instrumentation and instrument air equipment
- Effluent treatment facilities

3. Offsite facilities

a) Rock salt receiving facilities:
Consisting of storage yard for rock salt (including the yard for exports) and a belt-conveyor system for transporting the rock salt into the soda ash plant.

b) Carbon dioxide receiving facilities:
Comprising the carbon dioxide receiving facilities at the gas processing plant at Rayong and pipeline from there to the soda ash plant.

c) Ammonia receiving facilities:
Comprising the facilities for unloading imported ammonia at the port and pipeline from there to the soda ash plant.

4. Product storage and shipment facilities

5. Other auxiliary facilities (maintenance shop, office buildings, various structures and buildings)

5) Project implementation and management

5-1) Implementation schedule

The implementation schedule envisioned by the Study Team is as follows:

July, 1982 :	Start of construction
End of March, 1985:	Completion of plant construction
July, 1985 :	Start of commercial operation

5-2) Construction contract type

It is assumed that a turn-key, lump-sum contract will be used.

5-3) Need for technical assistance services

In view of previous experience in Thailand, it is anticipated that it will be necessary to acquire the following services from a qualified foreign company.

1. Technical assistance service for the selection of the specific process to be adopted and contractor, and for project management during the construction period.

2. Technical assistance service for operation and maintenance for two to three years after start-up.

Therefore, the cost for such services has been included in the estimation of required capital for the project.

5-4) Organization, manpower plan and training

It is expected that in addition to the soda ash plant, an office in Bangkok will be necessary. The staffing is to be as follows:

Executives	5 persons
Bangkok office	35 persons
Plant	833 persons
Total	873 persons

It will be necessary to train the employees, during the construction period, and the cost of such training including equipment needed for training is included in the estimate of the amount of capital required.

6) Managerial organization for promotion of the Project

It is believed that during the planning stage this project will be promoted by the Ministry of Industry of the Government of Thailand, but, moreover, it is necessary in order to have continuity and coherence as the project progresses from the planning stage to the construction and operation stages, for there to be mobilization of the key personnel of the company which is to be the key organization in the project implementation stage, and that those key persons be brought into the planning process so as to strengthen the project team and assure that an adequate implementing organization is established. Further, because there are many matters requiring coordination with various related agencies in order that this Project may be implemented, it is deemed necessary that a coordinating committee be established at the national level, and that a working team be formed, so that whenever a problem arises, it will be possible for there to be a quick response.

7) Consideration on prevention of environmental problems caused by effluents

By means of selecting manufacturing process and raw materials as well as process arrangements, careful consideration has been given to prevent the production of any harmful effluents and also to minimize the quantity of effluents. Moreover, it is planned that adequate treatment facilities will be established so that all effluents can be treated as required. As such, the soda ash plant of this Project will be equipped with appropriate facilities for preventing any environmental problems caused by plant effluents.

VI. CAPITAL REQUIREMENT, AND FINANCIAL PLAN

1) Total capital requirement

In the case that the costs of the required railway spur are to be borne by the Project, with the exception of interest during construction, the total capital requirement for this Project is estimated to be as follows:

(Unit: US$1,000)

	Foreign currency portion	Local currency portion	Total
Rock salt mine	23,433	30,252	53,685
Soda ash plant	246,891	104,118	351,009
Total	270,324	134,370	404,694

It is planned that 30% of the total capital requirement is to be met by equity, and that the other 70% is to be satisfied by long-term borrowing; because at the present time the source of a loan for this Project is not known, the terms and conditions cannot be known. In order to determine total capital requirements, and perform financial analysis, interest rates from 6% to 4% per annum are employed as a hypothesis, and the total capital requirement including interest during construction is as calculated and summarized below.

(Million US Dollars)

	Interest Rate: 6%			Interest Rate: 5%			Interest Rate: 4%		
	F.E.	L.C.	Total	F.E.	L.C.	Total	F.E.	L.C.	Total
Rock salt mine	27.0	30.3	57.3	26.4	30.3	56.7	25.7	30.3	56.0
Soda ash plant	270.5	104.1	374.6	266.3	104.1	370.4	262.3	104.1	366.4
Total	297.5	134.4	431.9	292.7	134.4	427.1	288.0	134.4	422.4

The above capital requirement calculation was made on the basis of late-1980 prices, and escalation of 9% per annum for the foreign exchange portion and 12% per annum for the local currency portion. This calculation assumes that commercial plant operation begins in July, 1985. If the schedule is delayed by a half year, an additional cost of 4.9% will be required and if a one-year delay ensues, the above requirement should be increased by 9.9%.

2) Financial plan

The financial plan based on the above total capital requirement is taken to be as follows:

(Unit: Million U.S. Dollars)

	Equity	Long-term borrowing
At 6% p.a. interest	129.6	302.3
At 5% p.a. interest	128.1	299.0
At 4% p.a. interest	126.7	295.7

VII. FINANCIAL ANALYSIS

1) Major assumptions for production cost estimates and for financial projections

Assuming that commercial operation begins in July, 1985, financial projections have been made using 1985 prices as constant prices. The conditions assumed for the projections are as follows.

1-1) Production and sales plan

1. Rock salt mine

As shown Table 11.

2. Soda ash and ammonium chloride

As shown in Table 12.

The years which are shown in these tables giving production and sales plans start at the beginning of July, 1985 through the end of June, 1986 as the first year, with each year starting and ending similarly thereafter. These production and sales plans have been formulated so as to be in conformity with the marketing outlook as given in part II above.

1-2) Sales price

A. Rock salt

The sales price of rock salt is set as follows:

	Price	(1985 prices) Terms of trade
1. Supply to soda ash plant	US$26/t	At soda ash plant gate
2. Sale within Thailand	US$30/t	Delivered to user
3. Export		FOB Laem Chabang
– Malaysia	US$29/t	
– Singapore	US$24/t	
– Non-ASEAN Taiwan	US$17/t	
Others*	US$16/t	

(Note) * Only in the case of 1.8 million t/y production.

Table 11 (1) PROJECTED SALES OF ROCK SALT
(Rated Capacity: 1,200,000 t/y)

(Unit: tons)

(Year)	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th
Capacity Utilization (%)	(68)	(70)	(79.4)	(85.5)	(86.7)	(88.5)	(89.8)	(91.3)	(92.7)	(94.1)	(95.5)	(97)	(98.4)	(99.8)	(100.0)
Production	816,000	840,000	952,800	1,026,000	1,040,400	1,062,000	1,077,600	1,095,600	1,112,400	1,129,200	1,146,000	1,164,000	1,180,800	1,197,600	1,200,000
Inventory Increase	136,000	4,000	18,800	12,200	2,400	3,600	2,600	3,000	2,800	2,800	2,800	3,000	2,800	2,800	400
Sales Volume	680,000	836,000	934,000	1,013,800	1,038,000	1,058,400	1,075,000	1,092,600	1,109,600	1,126,400	1,43,200	1,161,000	1,178,000	1,194,800	1,199,600
Supply to Soda Ash Plant	395,640	452,160	508,680	565,200	565,200	565,200	565,200	565,200	565,200	565,200	565,200	565,200	565,200	565,200	565,200
Thai Domestic Sales	87,400	116,450	145,700	158,500	171,300	184,400	197,800	211,200	224,600	238,000	251,400	264,800	278,200	291,600	305,000
Export to Malaysia	152,000	162,000	172,250	182,800	193,550	200,710	204,330	207,950	211,570	215,190	218,810	222,430	226,050	229,670	233,290
Export to Singapore	7,750	7,850	7,950	8,050	8,150	8,250	8,350	8,450	8,550	8,650	8,750	8,850	8,950	9,050	9,150
Export to Other Countries	37,210	97,540	99,420	99,250	99,800	99,840	99,320	99,800	99,680	99,360	99,040	99,720	99,600	99,280	86,960

Table 11 (2) PROJECTED SALES OF ROCK SALT
(Rated Capacity: 1,800,000 t/y)

(Unit: tons)

(Year)	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th
Capacity Utilization (%)	(70)	(80)	(90)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)
Production	1,260,000	1,440,000	1,620,000	1,800,000	1,800,000	1,800,000	1,800,000	1,800,000	1,800,000	1,800,000	1,800,000	1,800,000	1,800,000	1,800,000	1,800,000
Inventory Increase	210,000	30,000	30,000	30,000	0	0	0	0	0	0	0	0	0	0	0
Sales Volume	1,050,000	1,410,000	1,590,000	1,770,000	1,800,000	1,800,000	1,800,000	1,800,000	1,800,000	1,800,000	1,800,000	1,800,000	1,800,000	1,800,000	1,800,000
Supply to Soda Ash Plant	395,640	452,160	508,680	565,200	565,200	565,200	565,200	565,200	565,200	565,200	565,200	565,200	565,200	565,200	565,200
Thai Domestic Sales	87,400	116,450	145,700	158,500	171,300	184,400	197,800	211,200	224,600	238,000	251,400	264,800	278,200	291,600	305,000
Export to Malaysia	152,000	162,000	172,250	182,800	193,550	200,710	204,330	207,950	211,570	215,190	218,810	222,430	226,050	229,670	233,290
Export to Singapore	7,750	7,850	7,950	8,050	8,150	8,250	8,350	8,450	8,550	8,650	8,750	8,850	8,950	9,050	9,150
Export to Taiwan	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000
Export to other non-ASEAN countries	307,210	571,540	655,420	755,450	761,800	741,320	707,200	690,080	672,960	672,960	655,840	638,720	621,600	604,480	587,360

Table 12 (1) PROJECTED SALES OF SODA ASH
(Soda Ash: 400,000 t/y)

(Unit: tons)

	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th
Capacity Utilization (%)	(70)	(80)	(90)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)
Production	280,000	320,000	360,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000
Inventory Increase	23,333	3,344	3,333	3,333	–	–	–	–	–	–	–	–	–	–	–
Sales Volume	256,667	316,666	356,667	396,667	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000
Thailand	124,600	135,200	146,350	157,650	169,350	180,100	189,700	199,300	208,900	218,500	228,100	237,700	247,300	256,900	266,500
Singapore	15,950	16,000	16,100	16,200	17,300	18,650	19,200	19,750	20,300	20,850	21,400	21,950	22,500	23,050	23,600
Malaysia	44,300	47,400	50,650	53,750	57,300	61,500	65,650	69,800	73,950	78,100	82,250	86,400	90,550	94,700	98,850
Indonesia	71,817	103,200	109,900	116,850	124,000	131,600	125,450	111,150	96,850	82,550	68,250	53,950	39,650	25,350	11,050
Philippine	–	14,866	33,667	52,217	32,050	8,150	–	–	–	–	–	–	–	–	–

Table 12 (2) PROJECTED SALES OF AMMONIUM CHLORIDE
(Ammonium Chloride: 400,000 t/y)

(Unit: tons)

	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th
Capacity Utilization (%)	(70)	(80)	(90)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)
Production	280,000	320,000	360,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000
Inventory Increase	23,333	3,334	3,333	3,333	–	–	–	–	–	–	–	–	–	–	–
Sales Volume	256,667	316,666	356,667	396,667	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000
Thai Domestic Sales	256,667	316,666	334,700	350,950	366,100	179,200	379,200	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000
Exports to Non-ASEAN	–	–	21,967	45,717	33,990	33,900	8,800	–	–	–	–	–	–	–	–

B. Soda Ash

The sales price of soda ash was set on the basis of CIF price in each ASEAN country, and then the shipment price was projected by deducting ocean freights from the CIF prices. The financial projections use the shipment prices as summarized below.

(US$/t; 1985 prices)

	CIF Price	Freight	Shipment Price
Thailand	225	—	225
Singapore	229	15	214
Malaysia	230	17	213
Indonesia	229	19	210
Philippines	225	23	202

C. Ammonium Chloride

The sales price of ammonium chloride is set on a FOB Laem Chabang basis as follows:

	(1985 prices) Price (US$/t)
Domestic sales in Thailand	150
Exports	120

1-3) Taxes

1. Corporate tax

In accordance with tax law and industrial policy and related legislation in Thailand, it is axsumed that a tax holiday of eight years duration will be granted to the Project, and that after the expiration of that holiday the corporate tax rate will be 45% of taxable income.

2. Import duty and business tax

To be exempted.

3. Depreciation

Straight-line for 15 years.

1-4) Raw materials and utilities prices

Explained in the following section.

2) Production cost of rock salt, soda ash and ammonium chloride

2-1) Production cost of rock salt

1. On the basis of the above assumptions, the cost of rock salt has been estimated with the results as summarized below. The costs given here are those at the point of shipment from the mine site, and do not include the cost of rail transport.

(1985 prices base)

	Production Cost (US$/t)		
	6% interest	5% interest	4% interest
Variable cost	6.37 (6.37)	6.37 (6.37)	6.37 (6.37)
Fixed cost	4.14 (2.76)	3.93 (2.62)	3.73 (2.48)
Total cost	10.51 (9.13)	10.30 (8.99)	10.10 (8.85)

(Note) The figures show the cost at production of 1.2 million t/y, while those in parentheses showing the cost at 1.8 million t/y production.

2. Included in the variable costs cited above are dynamite, ANFO, blasting caps, fuel and other consumables used in the mine, as well as repair and maintenance costs, conveyor expansion costs, direct labor costs, fringe benefits, and general and administrative costs. Moreover, the equivalent of 4% of the rock salt sales price is taken as the amount to be paid as a royalty. Fixed costs comprise depreciation, tax and insurance, interest, etc.

3. As is clear from the above production cost data, the production cost of rock salt is at an appropriate level. However, if the transport cost of

US$10/t is added, the delivered cost at Laem Chabang without profit margin becomes US$18.85 to 20.10/ton for the case of 4% p.a. loan interest and US$19.13 to 20.51/ton for the case of 6% p.a. loan interest. Cost of the rock salt delivered at Laem Chabang increases to a high level, unless measures are taken for reducing rail charges.

2-2) Production cost of soda ash and ammonium chloride

1. The production cost of soda ash and ammonium chloride, as calculated on the basis of the assumptions given above, are as shown below. The production cost is that for a soda ash plant with the capacity of 400,000 t/y of soda ash and 400,000 t/y of ammonium chloride, operated at full capacity. Although, as mentioned above, the cost of rock salt to be used at the soda ash plant substantially varies depending upon the rates of rail charges, this calculation was made by using US$26/ton as a hypothetical rock salt cost.

(1985 prices base)

	Production Cost (US$/t)			
	Soda Ash	AC	Total	%
Variable cost	113.15	96.30	209.45	64.20
Fixed cost	63.10	53.70	116.80	35.80
Total cost	176.25	150.00	326.25	100.00

(Note) 1) Assuming 5% p.a. interest for purposes of cost estimates.
2) Soda ash cost computed by deducting the ammonium chloride sales price of US$150/t from the total production cost.

2. The above figures for variable cost include the costs of raw materials and utilities required to produce both soda ash and ammonium chloride. The fixed costs include the costs of plant maintenance and repair, depreciation, labor, general and administrative expenses, interest, etc. Prices of materials and utilities used for the estimation of variable cost are as follows:

a) Rock salt	US$26/t
b) Ammonia (imported)	US$235/t
c) Carbon dioxide	Zero value

d) Quicklime	US$28/t
e) Soda ash	US$225/t
f) Electric power	US$0.066/KWH
g) Water:	US$0.108/m^3
h) Fuel (Fuel oil)	US$227/m^3

3. Judging from the above figures, the cost of producing soda ash is substantially high. In comparison to the anticipated sales price as given above, it is expected that it will be difficult to obtain an adequate return on investment if production costs are at these levels. As the above table clearly shows, variable costs occupy a large share – about 64% – of total costs. In order to reduce the production cost, it is necessary to reduce the cost of raw materials and utilities.

4. Within the cost of raw materials and utilities, the shares accounted for by ammonia and fuel are high, being 36% and 23% respectively of the variable cost. On the other hand, the cost of rock salt accounts for a comparatively low share in the total variable cost. It is only 18% on the basis of the rock salt cost of US$26/ton. Sensitivity of soda ash cost affected by changes in the main raw material (salt), ammonia and fuel is shown in the following table.

	Change in product cost Soda Ash (US$/t)
Change in salt price ±10%:	±3.67
Change in ammonia price ±10%:	±7.52
Change in fuel price ±10%:	±4.72

As the levels of ammonia and fuel prices are substantially higher than that of salt price, as is shown in the above table, the cost of soda ash is greatly affected by changes in ammonia and fuel prices rather than salt prices. Hence measures for using ammonia and fuel at lower prices would be essential for reducing the cost of soda ash.

In the estimation of costs, it is assumed that ammonia will be imported, at the cost to the project of US$235/ton, and that fuel oil will be used as fuel, at the cost US$227/m^3 (Both of these are 1985 prices.). The price of ammonia is based on the international price of ammonia, whereas estimation of the fuel price is based on the present price of fuel oil in Thai-

land. As in the above pre-conditions, these costs are considered reasonable as long as imported ammonia and fuel oil are used for the project.

5. In order to reduce these costs, it is required for the Thai Government to take the following measures. That is, with regard to ammonia, the only possible move is that efforts may be made either to obtain ammonia produced at the natural-gas-based large ammonia plants in the surrounding countries (Indonesia and Malaysia) under a special price arrangement or to use ammonia produced at a fertilizer complex project. It is expected that in such an instance the price of ammonia could be reduced to about US$175/ton. Regarding fuel, it is recommended that the authorities discuss with PTT about measures for natural gas to be supplied to the soda ash plant. Because the price of this natural gas for industrial use has not yet been determined, only tentative observations may be made, but it may be stated that if the natural gas can be obtained at a per calorie cost equal to about 80% of that of heavy oil, it will be possible to make a major reduction in production cost.

6. If production cost is calculated on the basis of the above possibilities (ammonia; US$175/t, and fuel; US$181.60/m^3), and comparison is made with the production cost given in paragraph 1 above is made, it is found that the following cost reductions are possible, and greatly improve the cost competitiveness:

	Soda Ash Cost
Ammonia	US$19.70/ton
Fuel	US$ 9.44/ton
Total	US$29.14/ton

3) Financial analysis

3-1) Return on investment and profitability of the Project

1. Financial projections were prepared on the basis of the major assumptions given in above and for the project life of 15 years, and were used to project the return on investment as expressed in the internal rate of return (IRR). The results are as shown below.

	IRR (%)	
	Before Tax	After Tax
A. Rock salt mine	13.53 (14.19)	12.03 (12.70)
B. Soda ash plant	7.45	6.46
C. Entire Project	7.84 (8.01)	6.71 (6.93)

(Note) The figures show IRR for Base Case (1.2 million t/y), while those in parentheses showing IRR for Alternative Case (1.8 million t/y).

2. As shown above, the IRR has been estimated for the two profit centers of the Project, namely the rock salt mine (1.2 million t/y – Base Case, and 1.8 million t/y – Alternative Case) and the soda ash plant, as well as for the Project as a whole (both for Base Case and Alternative Case). The principal points used as assumptions for projecting the IRR area as follows.

A. Rock salt mine

Return on investment was calculated on the basis of sale of rock salt from the mine in part to the soda ash plant and in part to the domestic Thai and foreign markets. The production and marketing plans which form the basis for this are shown in Table 11; the sales price and sales conditions used are as given in above. Although the investment cost of railroad facilities other than related to the rail spur is not included in the required capital in these calculations, the cost for transport of rock salt from the mine to Laem Chabang, at the rate of US$10.00 per ton of rock salt, was included in the annual production cost of rock salt. Regarding the production scale of rock salt, two cases were assumed, one is 1.2 million t/y production as the Base Case, and the other is 1.8 million t/y production as the Alternative Case. The IRR figures shown above are for the Base Case, with the figures in parentheses for the Alternative Case.

B. Soda ash plant

Calculations were made on the basis of the assumption that the soda ash produced at the plant is made from rock salt purchased from the mine. Ammonia requirements are to be satisfied by use of imported

ammonia, and heavy oil is to be the fuel used. Consequently, the costs of these raw materials and utilities, as given in above, are; rock salt, US$26/ton; ammonia, US$235/ton; heavy oil, US$227/$m^3$. It is assumed that carbon dioxide will be obtained by recovering the gas which is separated from natural gas and is purged at the PTT's natural gas processing plant, as mentioned above, at no charge to the Project. The cost of carbon dioxide recovery facilities and the pipeline to the soda ash plant, however, is included as one of the costs of the soda ash plant and therefore is included in the capital requirement of the plant. Also included in the tabulation of required capital are: receiving facilities for imported ammonia; rock salt storage facilities as well as a belt conveyor system for transport of rock salt to the plant; export shipment facilities for rock salt and soda ash (a belt conveyor system to the pier and bulk loading facilities on the pier); and the cost of laying railroad spurs.

C. Entire Project

In determining the return on investment for the entire Project, the same assumptions as were employed in the case of the rock salt mine and soda ash plant, as described above, were used. Nevertheless, no revenue is imputed for rock salt consumed by the soda ash plant. Because the allocation of the capital costs related to railroad facilities (except rail spurs) has not yet been determined, only the costs for rail spurs have been included in the capital requirements for the Project. However, the cost for transport of rock salt at the rate of US$10.00 per ton of rock salt, as noted in A above, has been included in the annual operating costs.

3. As is evident from the above figures, as long as the assumptions used and specified here exist in reality, the return on investment for this Project does not exceed the minimum level agreed upon for ASEAN industrial project (8%). Because while the profitability of (A) the rock salt mine is reasonable, that of (B) the soda ash plant is not high, in order to improve the profitability of the entire Project, steps must be taken to improve the profitability of the soda ash plant in particular. The low level of profitability is ascribable to high costs relative to the expected sales price. As is discussed above, the causes of the high cost and countermeasures which may be taken to reduce cost as well as their influence to profitability are

as summarized below. (Regarding the sensitivity of the IRR as affected by changes in the major factors, see Figures 4 to 6.)

a) Rock salt mine

The cost of producing rock salt is not necessarily high, but the additional cost of transporting it from the mine to Laem Chabang by rail has the effect of lowering its cost competitiveness. It is therefore believed that tht best means of reducing the absolute cost of the rock salt is to reduce the cost of transporting it by rail. The sensitivity of the profitability of A. the rock salt mine and C. the entire Project affected by changes in the cost of rock salt transportation is as follows.

IRR after tax (%)	Rail transport cost			
	US$7/ton	US$8/ton	US$9/ton	US$10/ton
A. Rock salt mine	16.26 (19.40)	14.91 (17.31)	13.51 (15.08)	12.03 (12.70)
C. Entire Project	7.48 (8.08)	7.25 (7.71)	7.01 (7.33)	6.71 (6.93)

(Notes) 1) Upper sets of figures are for Base Case

2) Lower sets of figures, given in parentheses, are for Alternative Case.

As is evident from the above figures, in order to obtain an after-tax IRR of 8% or higher for the rock salt mine, it is necessary for the rail transport cost to be reduced to a substantial extent. Of course, if the price of rock salt to the soda ash plant is evaluated at different prices, as shown below, the IRR for the rock salt mine portion of the Project is changed, but it in turn affects the soda ash plant, so the IRR for the entire Project does not change.

b) Soda ash plant

The cause of the cost of soda ash and ammonium chloride being high, as is discussed above, is the high cost of ammonia and fuel, in absolute terms. Therefore, to reduce the cost of soda ash and ammonium chloride, measures for lowering the cost of ammonia and fuel must be taken. The following shows the sensitivity of profitability of the soda ash plant and the entire Project as affected by changes in the cost of ammonia and fuel.

Sensitivity of return on investment affected by changes in the ammonia price

IRR after tax (%)	Ammonia price		
	US$235/ton	-10% US$211.5/ton	-25% US$176.25/ton
B. Soda ash plant	6.46	7.22	8.32
C. Entire Project			
(Base Case)	6.71	7.42	8.36
(Alternative Case)	6.93	7.58	8.52

Sensitivity of return on investment affected by changes in the fuel price

IRR after tax (%)	Fuel price		
	US$227/m^3	-10% US$204.3/m^3	-20% US$181.6/m^3
B. Soda ash plant	6.46	6.95	7.41
C. Entire Project			
(Base Case)	6.71	7.18	7.58
(Alternative Case)	6.93	7.34	7.75

As is evident from the figures in the above two tables, in order to obtain an IRR after tax of 8% or higher for the soda ash plant portion of the Project, it is necessary for the ammonia cost to be US$180/ton or less, and for the fuel cost to be US$180/m^3 or less in fuel oil equivalent price (both in 1985 prices). As discussed in 2-2), if appropriate measures are taken by the Thai Government it is believed that these possibilities may be realized, for the following reasons.

(a) It is thought to be impossible to precisely determine, at this point, what the price of ammonia would be in such a case, but in view of general considerations of the cost of ammonia produced in large ammonia plants based on natural gas, it is expected that a price on the order of US$175/ton (1985 price) would be negotiable.

(b) At this time, the price at which natural gas would be supplied for industrial use is not known but judging from the precedent of other countries, in fuel oil equivalent price, it is thought that it will be negotiable so that the natural gas can be supplied at about

80% of the fuel oil price.

Further, in the event that the fertilizer complex is constructed in the vicinity of the soda ash plant, it will be possible to obtain from it carbon dioxide, a byproduct of the ammonia plant. That is, in the process of producing ammonia, carbon dioxide is generated, and other than that portion of the carbon dioxide that is used to make urea from the ammonia, there is no use for the gas and it is released into the atmosphere. It therefore should be possible to supply carbon dioxide to the soda ash plant by means of a pipeline. As is discussed earlier, according to present plans, a pipeline is to be constructed from the Rayong district site of the PTT natural gas processing plant to the soda ash plant for the supply of carbon dioxide, but if the fertilizer complex is constructed adjacent to the soda ash plant, the length of the pipeline which must be constructed would be reduced by a considerable extent and it will be possible to reduce the capital requirement for the soda ash plant by about US$20,000,000 relative to the sum estimated in this Evaluation Study. Sensitivity of the return on investment to the change in the capital requirement, for B. the soda ash plant and C. the entire Project is as follows.

Sensitivity of return on investment affected by changes in capital requirement

IRR after tax (%)	−10%	Original estimate	+10%
B. Soda ash plant	7.97	6.46	5.15
C. Entire Project			
(Base Case)	8.29	6.71	5.45
(Alternative Case)	8.46	6.93	5.60

4. In accordance with the conditions discussed thus far, if these prices are used, the after-tax IRR for the entire Project will be more than 8%:
   - Rail freight: US$7.4/ton (26% less)
   - Ammonia price: US$176.25/ton (25% less)
   - Fuel price: In fuel oil equivalent, US$181.6/$m^3$ (20% less)

   The IRR, using these prices, are as follows:

	IRR (Before tax)	IRR (After tax)
Base Case	10.97	9.69
Alternative Case	11.05	10.21

5) Alternative measure to be considered

For improvement of profitability it is desirable to conceive of measures which could secure the sale of soda ash at higher prices. Sensitivity of the return on investment to the change in the soda ash sales prices, for (B) the soda ash plant and (C) the entire Project is as follows.

Sensitivity of return on investment affected by changes in soda ash sales prices

IRR after tax (%)	-10%	-5%	Base Price	+5%	+10%
B. Soda ash plant	4.03	5.30	6.46	7.58	8.60
C. Entire Project (Base Case)	4.73	5.78	6.71	7.62	8.61
(Alternative Case)	4.90	5.95	6.93	7.80	8.76

6) The above analyses can be concluded with the following comments.

a) In order that this Project may have reasonable profitability, it is essential for the Thai Government to conceive measures to obtain lower cost ammonia and fuel and also to reduce rail transport cost as recommended earlier. Such measures are prerequisites for the Project to be financially viable.

b) Moreover, it is also important for the Government to conceive measures which can secure the sale of soda ash at prices higher than the projected prices.

c) This Project has possibilities to gain reasonable returns as the results of these measures taken by the Thai Government.

3-2) Financial structure of the project

1. If the prices of the rail transport, ammonia and fuel in actuality are substantially higher than projected here, there is no question but that the financial structure of the project will be weakened and profitability would be reduced. Therefore, it is the precondition for the Project to be financially viable that the above conditions are satisfied. Nevertheless on the assumption that these conditions will be as anticipated, the financial structure of the Project is as summarized in the following table.

	Interest Rate		
	6%	5%	4%
(1) Debt-service ratio 1.5 or higher	3rd yr (3rd yr)	3rd yr (3rd yr)	2nd yr (2nd yr)
(2) Internal rate of return on equity (IRRE)	13.48% (14.69%)	14.98% (16.18%)	16.46% (17.65%)

(Note) The figures show the indices for Base Case, while the figures in parentheses show those for Alternative Case.

2. As is shown by the above indices even after the above conditions are satisfied, until the third year, the financial structure does not warrant an optimistic view. Nevertheless, it is judged that the Project is financially self-liquidating, if the above conditions are satisfied.

3. Taking all of the above into consideration, it is judged that if the price level projected above for the three key factors (rail transport charges, ammonia cost and fuel cost) can be obtained so as to secure reasonable returns, that the Project becomes financially viable.

VIII. ECONOMIC EVALUATION

1) The economic significance to Thailand of implementing this project lies in development of the domestic reserves of rock salt, the use of that rock salt for production of soda ash and ammonium chloride, and use of those products as substitutes for what had previously been imported while at the same time contributing to attainment of economic sovereignty through exporting a portion of the production to ASEAN countries, while at the same time for the other ASEAN countries this project will provide an increase in regional trade and opportunities for investment whereby a contribution may be made to the expansion of the economy of each country.

2) From the viewpoint of Thailand as the country which is taking the initiative in promoting this Project, if evaluation of the project is to be undertaken by means of measuring the economic internal rate of return obtained through investment in this project, with an economic life of 15 years, the economic internal rate of return is found to be 15%, if the conditions discussed in the financial evaluation are satisfied.

3) For Thailand, this would be the country's first venture in the area of large-scale chemical industry, and this Project, while greatly contributing to future development by establishing a basic chemical industry, will also contribute to the economy through the creation of employment opportunities and through regional development effects which, considered together with repercussion effects in related industries, may be evaluated as making an extremely significant contribution to the economic development of Thailand.

4) On the other hand, this project is also evaluated as having great significance for the other ASEAN nations, by being a joint ASEAN project which contributes to ongoing efforts at creation and expansion of common ASEAN markets, and at promotion of industrialization within the region which makes best use of each ASEAN nation's comparative advantages, as well as attainment of increasing returns to scale through pooling ASEAN efforts. Through these means, the Project can make a significant contribution to the economic development of the ASEAN region.

CONCLUSIONS

The considered opinion of the Evaluation Team concerning the feasibility of the Project, based on the study summarized in the foregoing pages, is as follows.

1. Marketability of the products

1) The scale of the market in adjacent countries for rock salt produced by this Project, excluding the portion which is consumed in the soda ash plant, is not very large. The component of the international market price (CIF) of salt accounted for by ocean freight charges is very large. Moreover, the freight cost is directly influenced by the size of the vessel used to transport the salt. Australia and Mexico, the two largest scale exporter countries, use 60,000 DWT ships for their salt exports. In the case of Thailand, however, although it is not known if it will be possible to use such a large vessel for rock salt exports, to be unable to do so would serve to limit the export market to the countries adjoining Thailand.

Because there is no purchase guarantee provided by the ASEAN countries, it is necessary to export the rock salt under conditions of free market competition. This necessarily means that Thailand will have to compete with traditional large-scale exporters, such as Australia. Moreover, in the event that the Thai product is exported as industrial salt, it will have some handicap in competing with Australian products because of its slightly high insoluble material content.

In view of these conditions, it is anticipated that the quantity of rock salt which Thailand will be able to absorb in the domestic market, and export to adjacent countries, will be about 240,000 tons in 1985, and 390,000 tons in 1990. The quantity of rock salt which will be consumed in the soda ash plant will exceed the level of about 560,000 t/y. Although the combined quantity of rock salt is not as high as had been anticipated by the Thai Government, it is nevertheless at the level of the minimum economic scale for justification of development of the rock salt mine.

In conjunction with the quality of the Thai rock salt which is to be marketed as industrial salt, it is believed to be highly likely that it will be necessary to sell the salt at prices somewhat below the international market price, in order

to secure a market in the face of competition with other exporter countries.

2) It is projected that the scale of the soda ash market in the ASEAN region at the time that the project would begin operation, 1985, is at least 430,000 t/y, and would gradually increase until it reaches the level of about 590,000 t/y in 1990. Although the ASEAN nations have reached an agreement on their taking the soda ash produced by this project, if a conservative view is taken, it is forecast that the marketable volume of soda ash produced by this Project will be 370,000 tons in 1985, and 510,000 tons in 1990. This may be said to be an adequate scale to justify construction of a large soda ash plant.

3) There is a considerably large domestic market for ammonium chloride in Thailand. Moreover it is expected that market demand will increase and reach the level of 280,000 tons in 1985 and 370,000 tons in 1990.
Although exportation of ammonium chloride to other ASEAN nations may not be expected, it is believed to be possible to market 40,000 to 50,000 t/y outside of the ASEAN region. It is believed possible to market the entire quantity of ammonium chloride, which will be produced as a byproduct and in equivalent volume to soda ash, namely, 400,000 t/y.

2. Rock salt mine

1) It is proposed, in view of the above-described situation regarding the marketable volume of products, that the scale of production of the rock salt mine be 1.2 million t/y (two shifts). Nevertheless, it is possible to produce up to 1.8 million t/y by three shift operation, if marketing efforts require such scale of production. It is thought that the deposits of rock salt are adequate to support this level of mine output.

2) The quality of the salt, as industrial salt, appears to be somewhat inferior to that which is being exported to other countries which are potential importers of Thai rock salt, and although this requires that the price be reduced somewhat relative to international market level, it is judged that as long as this condition is met export sales are possible.

3. Rail transport of rock salt

1) The Project will require the construction of rail spurs at the rock salt mine

and soda ash plant, as well as the acquisition of hopper cars and marshaling locomotives, which are needed for the rock salt to be transported by rail.

2) If the cost of the above transport facilities are to be borne by this Project, the result would be a major influence on the cost competitiveness of the rock salt as the cost of transporting it would become very high. Plans also exist for development of potash resources in Northeastern Thailand, and this project too would face the same problem as cited here. It is therefore desirable for the Thai Government to consider comprehensive governmental measures on reducing rail transport cost, as one of the infrastructure problems to be solved in connection with the development of natural resources.

4. Soda ash plant

1) As a result of analysis and comparison of the alternate processes and production scales for the soda ash plant scheme, and with the consideration given to project economics and the problem of treatment and disposal of waste, the revised plan proposed is:

- Production process: Full AC Process
- Production scale: Soda ash, 400,000 t/y
  Ammonium Chloride, 400,000 t/y

2) It was proposed by the Thai Government that the site for construction of the soda ash plant is to be in Laem Chabang. There are no technical problems which would be encountered in constructing the plant at this site, but as a pre-condition for use of this site, it will be necessary for there to be coordinated construction by the competent ministries and agencies of port and harbor facilities, a water supply system, a power supply system, and other infrastructure.

3) It is proposed from the viewpoints of economics and waste treatment and disposal, rather than use limestone, to use substitutes such as carbon dioxide, quicklime, and soda ash. In this case, carbon dioxide should be acquired from PTT.

With regard to fuel, although this study is based on the use of fuel oil, it is recommended that efforts be made to use natural gas, thereby reducing fuel cost, through close coordination between the Ministry of Industry and PTT.

4) Although it is anticipated that ammonia required for the plant would be imported, as is noted, the prevailing high price of for ammonia would adversely impinge on the profitability of the project. If the Thai Government takes appropriate measures to obtain ammonia from the latter at a reasonable price, it would help assure the profitability of the soda ash plant operation. It is recommended that the Thai Government assign high priority to prompt and thorough study of this possibility.

5. Financial and economic evaluation of the project

1) The key to attaining adequate project economics and profitability for this project is:

- Rail transport cost
- Ammonia purchase price
- Fuel price

All of these must be kept at low levels.

2) The competitiveness of rock salt is greatly influenced by the cost of transporting it by rail. Moreover, because in the cost of producing soda ash the shares accounted for by ammonia and fuel are extremely large, the economics of soda ash production is greatly influenced by the price of ammonia and fuel.

3) If the measures recommended in sections 3 and 4 of this "Conclusion" are adopted, it is believed that the cost of the above three key factors can be reduced. If these measures are adopted by the Thai Government, then the requirement for project profitability agreed upon by the ASEAN nations as the minimum – an IRR of 8% – is considered to be attainable. In such a case, the financial structure would be such as to make the Project viable.

4) Further, if the above conditions are satisfied, this Project may be expected to provide a degree of economic contribution such as to justify the project.

To sum up the foregoing, it is evaluated, that provided that the following problems related in the "Conclusion" portion above are resolved along the lines proposed or suggested here, the Project would be technically feasible and have profitability to justify the investments.

(a) The completion of Laem Chabang Deep Sea Port by the time of completion of this Rock Salt-Soda Ash Project.

(b) Progress of the water supply project by IEAT along the implementation of the Rock Salt-Soda Ash Project.

(c) Assurance of electric power supply from EGAT.

(d) Any measures for reducing the cost for transport of rock salt by rail such that the capital cost of required rail transport facilities can concessionally be excluded from the financial scope of this Project and further that concessional freight rates are accepted.

(e) Assurance of the sources for supplying ammonia to the soda ash plant at a low price.

(f) Assurance of carbon dioxide supply from PTT.

(g) Assurance of using natural gas supplied at a low price or fuel oil at a concessional price.

RECOMMENDATIONS

It is recommended that the following be given most favorable consideration by the competent Thai authorities as part of the basis for decision-making as well as for implementation of the project.

1. Rock salt mine

1) Recommendation regarding mining survey

1-1) Surveys for determination of the thickness of the overburden by exploration

At the stage of detail design of the mine, it will be necessary to know the thickness of the overburden. The entry of surface run-off into working areas of the mine can cause great losses and may even make it necessary to close off portions of the mine. In order to prevent the entry of water into the mine, it is necessary to know the thickness of the overburden, and conditions related to fault zones and disturbed zones. Geophysical exploration will be the most economical way of obtaining the required information.

1-2) Minable rock salt quantity beyond 12 years of operation

The project line envisioned here is 12 years, and the extent of the minable deposits is equivalent to requirements for 30 years of mining at the rates now envisioned, so the extent of rock salt deposits is adequate. If mining is continued beyond 12 years, however, it will be necessary to have exploration done of areas to the north and lower strata. It is desirable that such exploration activities primarily include geological structure investigation including borings, chemical analysis and geophysical tests. It would be necessary to prepare a second mining program on the basis of these activities during the tenth year of mine operation.

2) Recommendation on environmental assessment

2-1) Precise measurement

It is possible that implementation of this Project will have adverse influences expressed or perceived at the surface of the ground above the mine. In order

to prevent such problems, measures such as lowering mining efficiency can be considered for adoption, but it is not possible to completely eliminate adverse influences. If such influences are great enough, measures such as revision of the mining plan are to be considered and adopted. In order to determine the extent of such influences, it is necessary to take precise measurements in advance of development and operation of the mine. Such measurements should include in particular determination of the elevation of the ground surface (precision: $5\sqrt{S}$ mm). At regular intervals after the start of mine operation (once in three months) measurements should be made in order to determine whether there has been any change, and the extent of that change, in ground level (interval of measurements on the surface 60–70 m).

2-2) Periodic fixed-point surveys of mined-out space

For the same reason as stated immediately above, it will be necessary to periodically survey fixed points in the mined-out spaces in accordance with the progress of mining. Any changes within the mine can be detected before they are measurable at the surface of the ground. The extent of any convergence of the distance between the roof and floor of the mining level, and measurement of the level of the floor, are of particular importance.

3) Recommendation relating to construction

3-1) Geological survey of proposed locations of structures and inclined shafts

Prior to final determination of the locations of the loading bunker, offices and other structures at the mine site, as well as the inclined shaft, geological surveys will be required.

3-2) Rock mechanics tests to determine the possible mining and pillar dimensions. The tests should included:

- Compressive strength
- Tensile strength
- Creep behavior
    - Short term (less than 100 days)
    - Long term (more than 100 days)
- Triaxial test

3-3) Detailed surveys

- Preparation of physical map
  (Scale: 1/500, 1/1000)
- Level survey
- Preparation of air photograph

3-4) Exploration work by applying a seismic method

3-5) Physical analysis of rock salt

After the mine shaft reaches the salt, it will be necessary to conduct tests of the physical properties of the salt in order to be able to determine the breaking and crushing equipment specifications. Such tests should be performed as frequently as possible and the test results should be used in conjunction with exploration data for planning of mining operations. The tests should include:

- Compression test
- Tensile strength test
- Creep test

2. Railway transport

It is recommended that the Thai Government coordinate the policies and programs of competent ministries and agencies so that the cost of rail transportation can be lowered, as described in the third section of the "Conclusion" above.

3. Soda ash plant

1) It is recommended that the final decision on construction of the soda ash plant be made on the basis of full coordination of the competent ministries and agencies of the Thai Government with regard to the improvement of infrastructure including construction of port and harbor facilities, a water supply system, etc. as mentioned in the fourth section of the "Conclusion".

2) It is further recommended that, as also noted in Section 4-4 of the "Conclusion" above, the possibility of obtaining low cost ammonia be given full consideration.

3) Study by the Thai Government through coordination with PTT of the possibility of supplying natural gas to the plant, as well as supplying carbon dioxide to the plant, is recommended to be undertaken, as noted in Section 4-3 of the "Conclusion" above.

4) If it is decided to proceed with this Project, it is recommended that a Project Team be organized at the earliest possible opportunity, and that an organization for promotion of the Project be established.

Figure 4 SENSITIVITY OF IRR (AFTER TAX)
(Rock Salt Mine — Base Case)

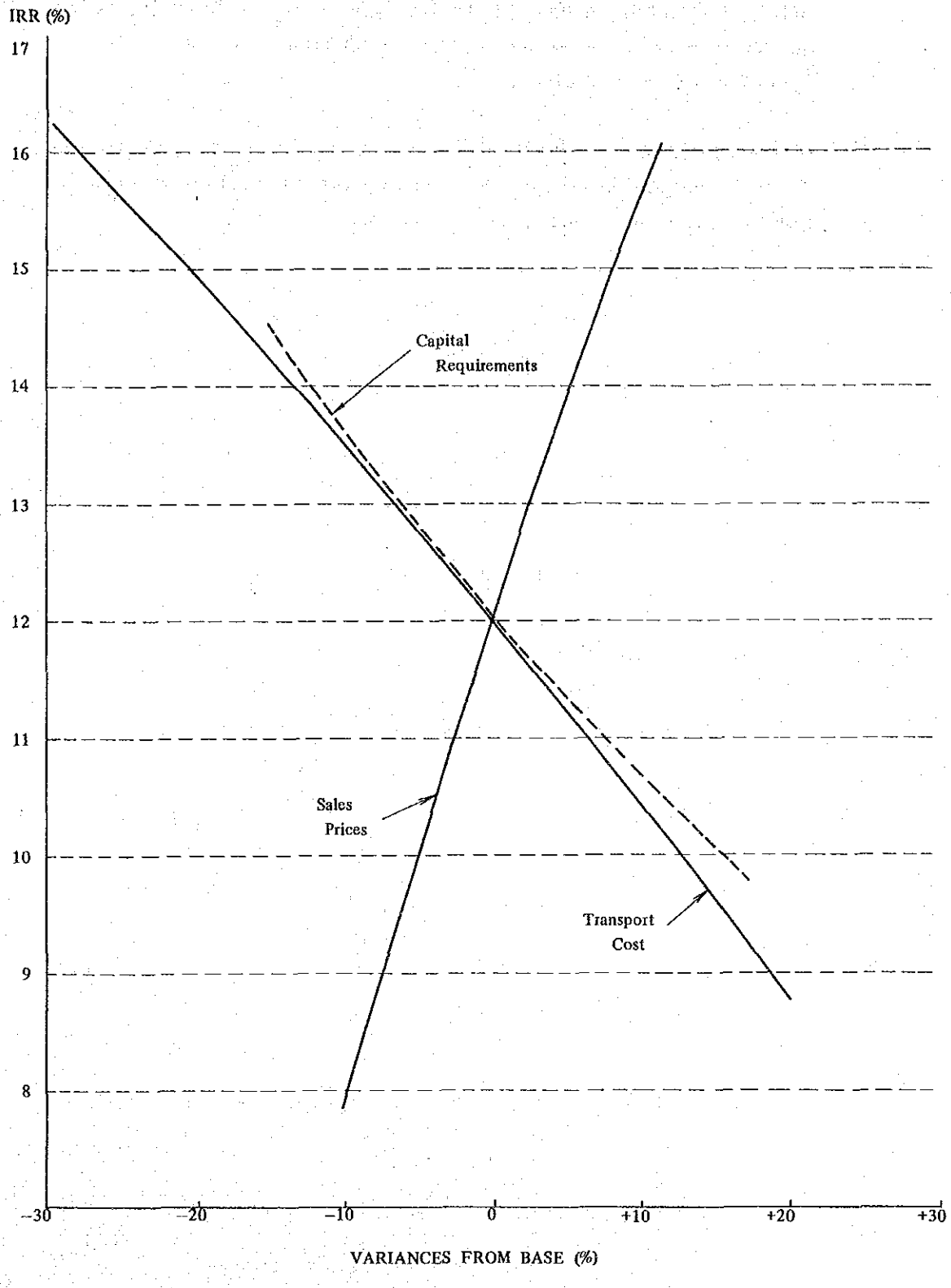
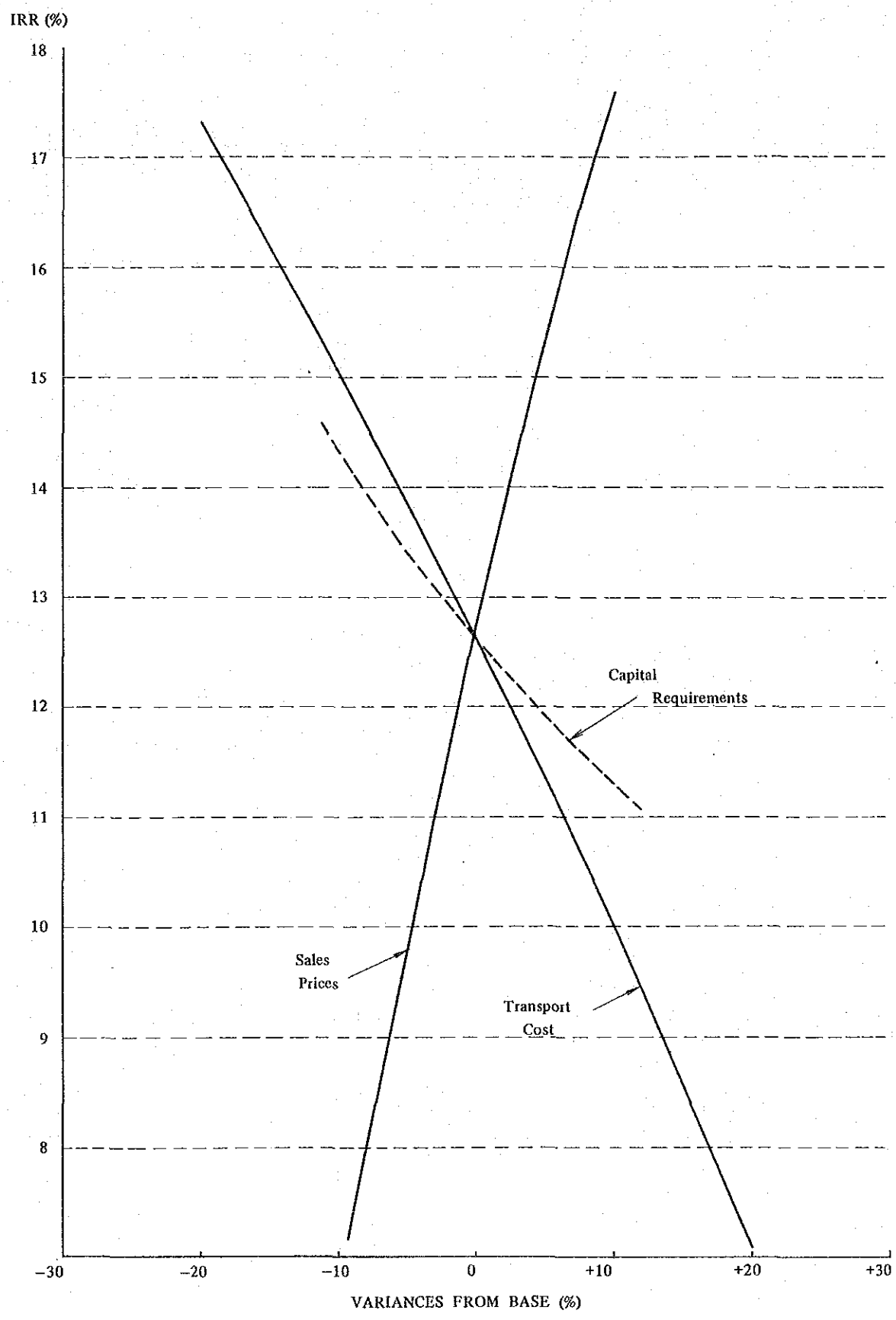


Figure 5 SENSITIVITY OF IRR (AFTER TAX)
(Rock Salt Mine — Alternative Case)



PART I

INTRODUCTION

PART I INTRODUCTION

CHAPTER 1 OBJECTIVES AND SCOPE OF THE STUDY

1-1 BACKGROUND AND OBJECTIVES

The ASEAN Rock Salt - Soda Ash Project which is the object of this Evaluation Study is one of the ASEAN Industrial Projects which the Government of Thailand (GOT) has been promoting. This project consists of two components, i.e., a Rock Salt Mine and a Soda Ash Plant, which are envisioned as summarized below.

Rock Salt Mine: To mine rock salt deposits present in Bamnet Narong, northeastern Thailand, with the intention to supply part of the produced rock salt to the Soda Ash Plant which is another component of the Project and to sell the remainder in the domestic Thai market as well as other ASEAN markets.

Soda Ash Plant: To establish a soda ash plant in Thailand which is to produce soda ash from the produced rock salt. It is the intention that the produced soda ash will be sold to ASEAN countries so as to meet the demand for soda of the glass industry and other soda ash consuming industries in these countries.

The GOT has made a feasibility study of this Project with the technical assistance of the Asian Development Bank. This study was undertaken by a Canadian firm, Surveyor, Nenniger and Chenevert Inc. (SNC), retained as the GOT's consultant.

The GOT formulated a proposal on the basic scheme of the Project (as briefly described in Chapter 3) on the basis of the aforesaid feasibility study, and this proposal, after being conceived by the COIME, was presented at the Seventh ASEAN Economic Ministers Meeting held in Kuala Lumpur in December, 1978. As a result, the member countries have agreed on the fundamental concept of the Project and to take necessary steps for the finalization of the Project.

As one of the measures taken in order to elaborate the basis of the Project, the Japanese Government was requested to assist in precisely reviewing and examining the Project, and thus Japan International Cooperation Agency (JICA) has undertaken this study.

In accordance with the above request of the GOT, in March, 1979, a pre-study mission organized by JICA conducted a preliminary survey to identify major problem areas for the study. As a result, there were various findings presented by the mission, with recommendations that, prior to the evaluation study, the following steps be taken by the GOT.

1. To conduct four additional drillings at the Bamnet Narong area in order to produce and collect further data which are required for detailed investigations and examinations with regard to the rock salt mine.

2. To select a definite site where the soda ash plant is to be constructed.

3. To organize a counterpart team which will work with the Japanese Evaluation Study Team in carrying out the evaluation study.

Agreement was reached by the governments of both Thailand and Japan that the evaluation study be commenced after the above steps have been accomplished. Regarding the additional drillings stated in (a) above, the Department of Mineral Resources of the GOT's Ministry of Industry immediately commenced the work, and for this end the JICA provided the GOT with necessary technical assistance with regard to the selection of drilling points, preparation of samples for analysis as well as the analysis of the samples. The result of the sample analysis was submitted by JICA to the GOT in September, 1980 in the form of a report titled the Technical Report of the First Stage Evaluation for ASEAN Rock Salt – Soda Ash Project in Thailand.

With regard to the soda ash plant site, Laem Chabang was selected by the GOT with the approval of the Cabinet in June, 1980. At the same time, organization of the Thai counterpart team proceeded. With the satisfactory completion of the agreed steps, in July, 1980, the GOT requested the Japanese Government to proceed with the evaluation study by JICA.

The foregoing is the background of this evaluation study which has as its objectives to review and supplement as necessary the feasibility study of this Project which had been made by the GOT and, based on the thus studied results, to evaluate the feasibility of the Project.

In this context, the study was made on the basis of the Project concept proposed by the GOT. However, as the result of studies, the Evaluation Study Team observes that the proposed concept is not feasible, and thus proposes hereby an alternative concept as is stated in this report although it substantially diverges from the original plan.

1-2 SCOPE OF THE STUDY

To meet the objectives of the study stated above, the scope of the study was broadly set out as follows. (Attached as Annex I-1 is a copy of the minutes of discussion concerning the work program which has been agreed between the Japanese Evaluation Study Team and the Thai Counterpart Team.)

1. The forecast of outlook for the sale to Thailand and other ASEAN market, and the sales plan, of rock salt, soda ash and its byproduct (ammonium chloride)

2. Study of development planning of the rock salt mine

3. Study of transport of rock salt

4. Study of development planning of the soda ash plant

5. Estimation of the capital costs required for the construction of rock salt mine, soda ash plant and other relevant facilities in this Project, and financing plan for Project.

6. Projection of the production costs for rock salt, soda ash and its byproduct produced at this Project

7. Financial projections and financial analysis of this Project

8. Economic evaluation of this Project

9. Overall evaluation of this Project based on the foregoing studies

Detailed investigations and examinations were made concerning each of these elements. Major premises taken for these investigations and examinations are summarized in 1–3 in order to provide the basis for this study.

Moreover, it is noted that, regarding the study of quarrying limestone, examinations were to be made only in the event that this study resulted in a project concept by which the soda ash plant is to use limestone in such a large quantity that the quarrying of limestone is feasible.

1-3 MAJOR STUDY PREMISES

Major premises taken for this study are as summarized below.

1-3-1 Site for the Soda Ash Plant

It was the precondition for the commencement of this study that the GOT would select a definite site for the soda ash plant. Prior to the commencement, it was proposed by the GOT that the site for the plant be Laem Chabang. In accordance with this proposal, the evaluation study was limited to evaluating from technical and economic points of view the proposed site with regard to suitability of the site for construction and operation of the plant.

1-3-2 Pollution/Environmental Aspects

Pollution and environmental problems which may occur in connection with industrial development can be divided into two categories in view of the nature of problems encompassed in these aspects.

1. Problems directly related to the plants established

   Pollution which may occur due to waste materials, liquid effluents, gaseous emissions of the plants

2. Problems indirectly related to the plants established

   Affects to natural environment in connection with urbanization which may occur when industrial development progresses.

   The latter problems comprise the fundamental issues which call for national level studies to be made by competent authorities of the GOT in the process of conceiving national plans for industrial development or regional development. The evaluation of such fundamental issues which relate to the national policy would be beyond the nature of this evaluation study, and this study therefore is limited to technical examinations on appropriate process technologies and other measures to control effluents from the Project.

1-3-3 Development of Relevant Infrastructure

This Project requires the existence of infrastructure (such as a port and harbor, and railway system), for inland transportation of the produced rock salt or the shipments of rock salt and soda ash for export, and the development of these facilities therefore is vital for the success of the Project. Moreover, such need exists not only for this Project but also the development of other industrial projects. Hence in this study it was assumed that this Project will have a minimum scope of infrastructure directly required for the Project and, for other items, will rely on the infrastructure developed by the GOT for public use.

CHAPTER 2 OUTLINE OF PROJECT EXECUTION

2-1 MANNER AND SCHEDULE

In due consideration of the importance of the Project, JICA has organized an evaluation study team (the Evaluation Study Team) headed by Mr. Masayasu Sakanashi and consisting of eleven other experts. [1)]

The Evaluation Study Team accompanied by four officers in charge who were assigned from the ministries or agencies concerned of the Japanese Government, visited Thailand for field surveys lasting 23 days beginning September 10, 1980. This study was made by through investigation and examinations of the findings, data and information obtained through the field surveys. Of the Team's members, a market expert visited Malaysia, Singapore, Indonesia and the Philippines, in addition to Thailand to survey the entire ASEAN countries market.

To assist in the field surveys, a counterpart team was organized. Headed by Mr. Chana Nilkuha, Deputy Director of Mineral Resources, the Ministry of Industry, it consisted of staff members of the Department.[2)] During the field surveys[3)], the Evaluation Study Team collected and analyzed necessary data and information by working with and discussing matters in detail with the Thai counterpart team. The Evaluation Study Team also made investigations of site conditions of the alternative sites for the Rock Salt Mine as well as the Soda Ash Plant and also the present status of relevant industries in Thailand in order to identify underlying problems.

2-2 OUTLINE OF THE STUDY

In light of the scope of this study stated in 1-2 of this Part, the main areas to be studied may be classified as follows.

(Notes) 1) Names of the members of the Evaluation Study Team are listed in Annex I-2.

2) Names of the members of the Thai counterpart team are listed in Annex I-3.

3) Names of the offices visited by the Evaluation Study Team are the schedule of the field surveys in Thailand are shown in Annex I-4.

1. Market study

2. Examination of technical aspects of development planning of the Rock Salt Mine

3. Examination of limestone quarry and suppliability

4. Study of the railway system in Thailand which is utilized for transport of rock salt

5. Examination of technical aspects of development planning of the Soda Ash Plant

6. Estimation of the capital requirements and financing plan for the Project

7. Financial projections and analysis, and economic evaluation of the Project

8. Overall evaluation of this Project

The outline of studies made on each of these areas are set out as follows.

2-2-1 Market Study

The primary objective of the market study was to examine the possibilities of marketing rock salt and soda ash to the ASEAN markets. With regard to rock salt, however, in addition to this study, the Evaluation Study Team examined the possibilities of exporting the product to outside the ASEAN region. Similar studies were made on ammonium chloride as well which is to be produced as a by-product depending upon the soda ash manufacuring process adopted for the Project.

In addition to the above, the Evaluation Study Team attempted to predict the future tendency of international prices for salt, soda ash and ammonium chloride, which prices are used as a basis for the financial evaluation of this Project. The outcome of these studies are described in Part II and Annex II of this report.

2-2-2 Examination of Technical Aspects of Development Planning of the Rock Salt Mine

The rock salt deposits to be mined by this Project exist in the Bamnet Narong area, northeastern Thailand. With regard to the rock salt deposits in this area, for exploration 24 drillings (of which four drillings were performed during the JICA's first evaluation study) have been made. This study was to examine technical aspects of development planning of the rock salt mine on the basis of drilling data as well as the results of analysis of drilling samples collected by the above activities. The study included the following aspects.

1. Selection of the mining site and mining zone, estimation of the minable reserves, assessment of the rock salt quality, and defining of the bases for designing the mine

2. Availability of utilities, and the present status of development and availability of related infrastructure

3. Selection of mining method, defining of the scope and scale of the mine facilities and relevant facilities, and conceptual design of these facilities

4. Examination of pollution control measures

5. Examination of construction method and implementation program

6. Examination of organization and manpower requirement for the mine, and management and operation of the mine.

The outcome is stated in Part III and Annex III of this report.

2-2-3 Examination of Limestone Quarry and Suppliability

The GOT envisaged a plan to quarry limestone which exists at the Khaw Pang Sak area, about 45 km northeast from Sarabri, northeastern Thailand. Limestone requirements, as stated earlier, vary depending upon what process is adopted for the manufacturing of soda ash and what materials are used as carbon dioxide and calcium sources, so it was the provision for the study of this aspect that examinations are to be made only in the event that the study of the soda ash plant part results in a concept by which the soda ash plant is to use limestone in such a large quantity that this use makes limestone quarrying feasible. The outcome is stated in Part V and Annex V of this report.

2-2-4 Study of the Railway System for Transport of Rock Salt

It is the GOT's plan that the produced rock salt be transported to the soda ash plant site by use of the railway. The study of this area comprises the study of conditions of the railway en route for transport of rock salt as well as the possibilities to use the railway. The study also included examinations of measures to be taken for utilizing the tracks. The outcome is stated in Part IV of this report.

2-2-5 Examination of Technical Aspects of Development Planning of The Soda Ash Plant

It was the GOT's proposal that the Soda Ash Plant is to be located at Laem Chabang. Site conditions of this area were investigated. Examination of the plan for the Soda Ash Plant was based on the results of the above site studies, and was initiated by technical and economic comparison of the following alternative processes and selection of the optimum scheme including a process to be adopted.

1. Solvay process
2. Partial ammonium chloride (AC) co-production process
3. Full AC co-production process

With regard to the development planning of the soda ash plant, the main areas studied comprise the following items.

1. Evaluation of suitability of the soda ash plant site proposed by the GOT
2. Possibilities of utilities supply, and the availability of related infrastructure
3. Selection of the optimum process and capacity for the soda ash palnt
4. Examination of appropriate measures to be taken for pollution control
5. Definition and conceptual design of plant facilities
6. Examination of construction method and implementation program

7. Examination of organization and manpower requirement for the plant, and management and operation of the plant

The results of the above studies are stated in Part V and Annex V of this report.

2-2-6 Estimation of Capital Requirements and Financing Plan for the Project

On the basis of the scope and scheme defined as the results of the foregoing studies, the Evaluation Study Team estimated the capital requirements for this Project and then formulated financing plans. These are compiled in Part VI of this report.

2-2-7 Financial Projections and Analysis, and Economic Evaluation of the Project

On the basis of the capital requirements projected by the work as stated above and other cost elements, the Evaluation Study Team estimated the production cost of rock salt, soda ash and ammonium chloride, and then made the financial projections and analysis as well as the economic evaluation of this Project, whereby the financial viability and economic effects of this Project. The outcome of these analyses and assessments are compiled in Parts VII and VIII of this report.

CHAPTER 3 BASIC AGREEMENT AMONG ASEAN MEMBER STATES CONCERNING FUNDAMENTAL ASPECTS OF THIS PROJECT AND PRESENT STATUS OF PROJECT PREPARATION

The basic concept and conditions for this Project have been agreed in principle at the ASEAN Economic Ministers Meeting held in Kuala Lumpur, Malaysia in December, 1978. In accordance with the information provided by the GOT in the course of this study, this Chapter summarizes the basic agreements made among the ASEAN member states and the present status with regard to this Project.

3-1 OUTLINE OF THE PROJECT

Outline description of a project concept which was proposed by the GOT to the ASEAN Economic Ministers Meeting and agreed at the Meeting is as follows.

1. Rock Salt Mine

   a. Mining site: Bamnet Narong (about 225 km northeast of Bangkok)

   b. Mine scale: Initial scale of 1.6 million t/y (to be expanded later to 2.5 million t/y)

2. Soda Ash Plant

   a. Plant site: Laem Chabang

   b. Plant capacity: Initial capacity of 400,000 t/y of soda ash (to be expanded later to 500,000 t/y)

3. Limestone Quarry

   a. Quarry site: Khaw Pang Sak (about 45 km northeast of Saraburi)

   b. Quarry scale: To be determined so as to meet requirements by the Soda Ash Plant

3-2 EXECUTION ENTITY OF THIS PROJECT

As soon as the implementation of this Project is finally decided, the ASEAN member states will proceed with establishing a joint-venture company in Thailand to engage in the implementation of the Project. The company will be incorporated with joint investment of these states under the relevant laws in force in the Kingdom of Thailand.

The outline of the company is as follows.

Equity capital: Equivalent to 30% of the total capital required. On the basis of the outcome of this study. (The total capital budget required for the Project will finally be determined at an ASEAN Economic Ministers Meeting.)

Ownership: Percentages of ownership among the ASEAN member states is as follows.

Thailand	60%
Indonesia	13%
Malaysia	13%
Philippines	13%
Singapore	1%
	100%

Manner of subscription: The respective governments of the ASEAN member states will establish or appoint a certain shareholding company for this Project respectively in each state, and these entities will subscribe to equity shares of the joint-venture company in accordance with the percentage of the company's ownership stated above.

The GOT has already established a pilot company named Rock Salt and Soda Ash Shareholding Co. with the equity capital of 2 million Bahts. This company is to be the shareholding entity, representing Thailand, of the joint-venture company. Ownership of the pilot company is one-third by the GOT and the remaining two-thirds by ten private Thailand companies. The capital of the company is to be increased in the later stage as required for subscribing its shares in the joint-venture company. Other shareholding entities which will represent the other ASEAN states are yet to be appointed by them respectively.

3-3 RESPONSIBILITY FOR THE EXECUTION AND MANAGEMENT OF THE PROJECT

The Thai shareholding company stated above (Rock Salt and Soda Ash Shareholding Co.) is so far a pilot company, so this company, at present, has no organizational structure to undertake neccssary work for project preparation. The GOT's Ministry of Industry therefore assumes direct responsibility for the project preparation. The GOT, however, intends to establish the management structure of the above company by the time when the implementation of the Project is commenced, so that it can be responsible for the management of the Project.

3-4 BASIC AGREEMENT AMONG THE ASEAN MEMBER STATES WITH REGARD TO MARKETING OF THE PRODUCT OF THIS PROJECT

With regard to marketing of the products produced by this Project, the basic agreements made among the ASEAN member states are as summarized below.

1. Priority given to the Project with regard to the sale of the products to the ASEAN markets: It was agreed that this Project will have priority on the sale of soda ash to the ASEAN markets, but it will not have such priority on rock salt and ammonium chloride.

2. Guarantee on the offtake of soda ash: The respective ASEAN member states will guarantee to take off the soda ash produced by this Project in accordance with the Preferencial Trading Arrangements.

3. Sales price of soda ash: The sales price of the soda ash will be set at international prices in terms of CIF in each importing country of the ASEAN region, with ceiling and floor prices which are determined so as to meet a maximum and minimum of returns on investment, i.e., ROI 20% as maximum and 8% as minimum.

PART II

MARKET STUDY

PART II MARKET STUDY

The major objective of the market study is to clarify the following points in connection with the rock salt to be mined as a major part of the undertaking of the proposed Project, and the soda ash to be produced in the plant to be constructed for that purpose as a second major part of the Project. Study was also made of the ammonium chloride to be produced as a by-product depending on the soda ash process employed.

1. Present scale of demand and outlook for the future for demand of the above products (rock salt, soda ash and ammonium chloride) in the ASEAN market. (If deemed necessary, the study is to be extended to beyond the ASEAN market.)

2. Marketable volumes of the above products in the ASEAN market (and beyond the ASEAN region if required).

3. Anticipated market prices for the above products, such prices to be used for determination of the sales price to be used in financial analysis of the Project.

4. Problems which may exist in relation to the distribution and marketing of the above products, and countermeasures, as required for use in studying the marketing plan for the products.

The ASEAN governments have reached agreement to the effect that each will guarantee to purchase soda ash produced by means of this Project, in accordance with their requirements. No such guarantees have been made with regard to rock salt and ammonium chloride. This study takes into consideration different sets of market conditions for the soda ash on one hand and the rock salt and ammonium chloride on the other.

The following portions of this chapter give only the results of study of the points cited above; details related to the study are provided as Annex II. Although this study was undertaken with the understanding that it was to be a review of the feasibility study conducted by the GOT in 1977-1978, because the market situation has changed considerably since the time of that study, and because the present study revealed new points of high importance, the study has been performed with an emphasis suitably given to the latter. The comparison with the earlier feasibility study is given in Annex II.

CHAPTER 1 SODA ASH

1-1 SODA ASH MARKET IN THE ASEAN NATIONS

1-1-1 Demand for Soda Ash in the ASEAN Nations

At present, all of the ASEAN nations are totally dependent upon imports as their supply of soda ash. The trend of soda ash imports by the ASEAN countries is as shown in Table II-1. Although the existence of year-end carryover stocks indicate that statistics for imports cannot be taken as-is as representing the level of demand, these statistics may nevertheless be used in order to obtain a generally adequate understanding of the level of demand. As may be seen in Table II-1, for 1977-1979 (1976-1978 in the case of Malaysia) the average annual volume of imports of soda ash (apparent consumption volume) by the five ASEAN countries together is 221,000 tons. The largest national share is that of the Philippines which accounts for 32% of the average import volume, followed by Thailand with 27% and Indonesia with 22%.

As an example of the pattern of end-use of soda ash, the situation in an advanced country (the United States) is as follows.

Typical End Uses of Soda Ash

(USA, 1978)

End use	% of ash consumed
Glass	57
Chemicals	25
Pulp and paper	6
Water treatment	4
Others	8
Total	100

In contrast to this, the great majority of soda ash consumed in the ASEAN nations is used for glass production. As shown by Table II-2, the ratios are such that 82% of soda ash consumption in the ASEAN nations is for glass. The use which is second in importance is that of raw material for sodium silicate production; this accounts for 9% of total consumption. Regarding other uses, the pattern varies from country to country depending on the pattern and scale of demand. In the Philippines, production of sodium tripolyphosphate

Table II-1 IMPORTS OF SODA ASH BY ASEAN COUNTRIES

(000 tons)

	1975	1976	1977	1978	1979	1977 – 79 Average [1]	
Thailand	34.6	48.1	60.8	39.8	66.9	55.8	(25.7)[3]
Indonesia	23.6	39.3	41.4	65.1		48.6	(22.4)
The Philippines	46.2	67.7	61.0	69.1	81.6	70.6	(32.6)
Malaysia	15.2	21.3	28.1	29.5		26.3	(12.1)
Singapore [2]	7.2	14.2	11.9	12.6	22.1	15.5	(7.2)
Total	126.8	190.6	203.2	216.1		216.8	(100.0)

(Notes) 1) For Indonesia and Malaysia: Average of 1976 – 78.
2) Net imports.
3) ( ): Percentage of total.

Sources:
- Thailand — Department of Customs, "Foreign Trade Statistics of Thailand".
- Indonesia — Central Bureau of Statistics, "Foreign Trade Statistics".
- The Philippines — National Economic Development Authority, "Foreign Trade Statics of the Philippines".
- Malaysia — Department of Statistics, "Annual Statistics of External Trade".
- Singapore — Department of Statistics, "Singapore External Trade Statistics".

Table II-2 CONSUMPTION OF SODA ASH BY USER INDUSTRIES IN ASEAN COUNTRIES, 1978 OR 1979

(000 tons)

	Sheet Glass	Bottle/Container Glass	Sodium Silicate	Others	Total
Thailand [1)]	17.8	40.2	7.4	1.5	66.9
Indonesia	12.7	47.2	4.0	1.2	65.1
Malaysia	5.9	14.2	4.6	4.8	29.5
The Philippines [1)]	8.0	53.5	4.5	15.6	81.6
Singapore	–	10.1	2.0	0.5	12.6
Total	44.4	165.2	22.5	23.6	255.7
(% of Total Demand)	(17.4)	(64.6)	(8.8)	(9.2)	(100.0)

(Note) 1) Consumption in 1979.

Sources: Tables AII-1, AII-10, AII-15, AII-19, and AII-22 in Annex-II.

(STPP) accounts for a relatively high percentage of demand, whereas in Malaysia use of soda ash for production of monosodium glutamate (MSG) is at a high level.

The general flow whereby soda ash is used for intermediate products which are in turn made into final products is as shown in Figure II-1. Study of the situation in the ASEAN nations, however, reveals a flow pattern which is different, in each country, from this one. The major differences are as follows.

1. No ASEAN nation other than the Philippines produces STPP. Ergo, all countries other than the Philippines are dependent on imports as their source of STPP supply.

2. With the exception of Malaysia, all ASEAN nations use caustic soda rather than soda ash as the main raw material for production of MAG. Ergo, the volume of ASEAN demand for soda ash for MSG production is minute.

3. In the case of such countries as Japan and USA, there is demand for soda ash for desulphurization in steel-making, and demand for soda ash for use in the pulp industry, but in the ASEAN countries, because caustic soda is used in place of soda ash, there is no outlook for soda ash demand in these industries.

The results of projection of future demand for soda ash in the ASEAN countries, made by the Evaluation Team, are shown in Table II-3. For this projection, the method used was to project the development of production for each industry using soda ash, in each country, and to determine the rate of growth and level of soda ash demand in keeping with that. Details relating to the method of making the projection, as well as information on the present conditions and outlook for soda-ash-using industries in the ASEAN countries, are given in Annex II.

As may be seen in Table II-3, whereas the total demand for soda ash in the five ASEAN countries in 1978 was about 216,000 t, it will increase to 430,000 t in 1985, and to 593,800t in 1990. By country, in Thailand from 1979 to 1990 demand will increase by 9.2% p.a., while in Indonesia and Malaysia during the 12 years from 1978 to 1990, demand will grow by 8.3% and 8.0% p.a., respectively. In contrast to this, the relatively low growth of 5.5% p.a., is expected for the Philippines for the 11 years from 1979 to 1990. During the same period, demand in Singapore will grow only by 1.6% p.a. The reason for these differences in growth rates from country to country is ascribed to differences between these countries with regard to the structure of industry and pattern of personal consumption (level of use of soap and

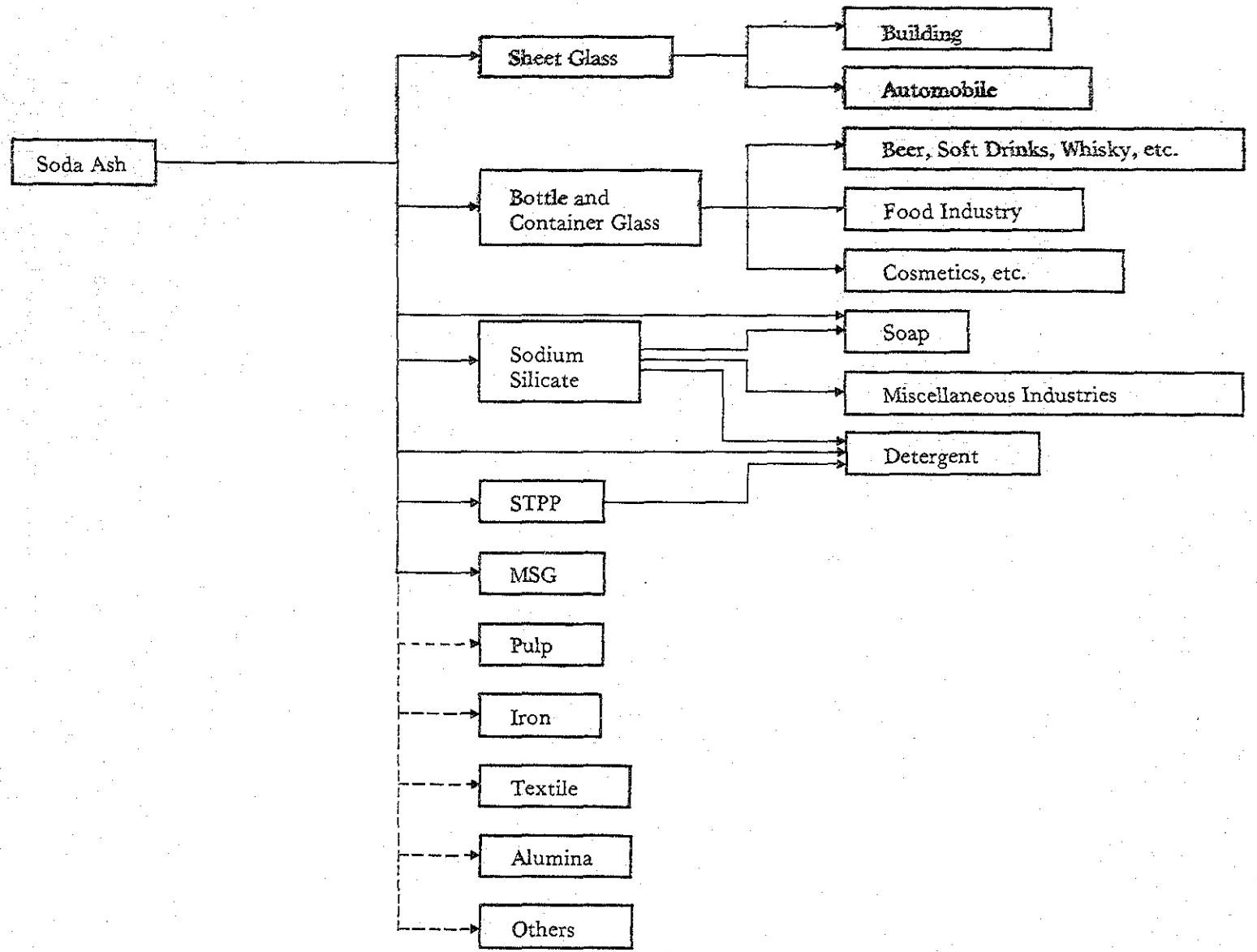


Figure II-1 DEMAND FLOW OF SODA ASH

Table II-3 PROJECTED DEMAND FOR SODA ASH IN ASEAN COUNTRIES

(000 tons)

	Thailand	Indonesia	The Philippines	Malaysia	Singapore	Total
Actual:						
1978	39.8	65.1	69.1	29.5	12.6	216.1
1979	66.9		81.6		22.1	
Projected:						
1985	119.6	124.6	109.1	53.5	22.7	429.5
1986	129.6	133.2	115.8	57.2	22.8	458.6
1987	140.8	142.0	122.9	61.2	22.9	489.8
1988	151.9	151.1	128.2	65.4	23.1	519.7
1989	163.4	160.5	138.3	69.0	23.1	554.3
1990	175.3	170.1	146.7	74.2	26.3	592.6
1995	242.8	223.3	193.3	100.3	30.1	789.8
Average Annual Growth Rate (%) (1979 – 1990)	9.2	8.3 [1)]	5.5	8.0 [1)]	1.6	8.8 [1)]

(Note) 1) Average annual growth rate from 1978 to 1990.

Sources: Tables AII-1, AII-10, AII-15, AII-19, and AII-22 in Annex-II.

detergent, consumption of soft drinks, etc.) as well as differences in economic growth rates. Further, in the case of Singapore, most industries which use soda ash are export-oriented industries. Therefore, domestic demand for soda ash is not linked to domestic demand for products made using soda ash. On the basis of these conditions, with regard to soda ash demand in Singapore, future projections were made only on the basis of the present conditions in soda-ash-using industries and firm expansion plans in these industries. Therefore, it is felt that the demand outlook for Singapore used in this study is prone to be an under-evaluation. Nevertheless, because the share of Singapore in the total ASEAN demand for soda ash is so small, it is believed that any under-estimation of Singapore's demand will not have great impact on the study.

Table II-4 presents the outlook for soda ash demand by user industry. Among the total of 593,000 t projected as ASEAN demand in 1990, 83% is accounted for by the glass manufacturing industry, and 9% by the sodium silicate industry. That is, it may be thought that in the future period of concern here there will be virtually no change in the structure of soda ash demand in the region.

1-1-2 The Quality and Specifications of Soda Ash Needed in the ASEAN Market

Soda ash is either dense ash (bulk density 1.0 to 1.2) or light ash (bulk density 0.8 to 1.0), but in general dense ash is used in the ASEAN countries. In the glass industry in these countries in the past, when there was an insufficient supply of dense ash, some plants made temporary use of light ash. Based on this experience, the industry sources pointed out that the light ash was difficult to handle and, further, lowered the input-output ratio in the production. Therefore, there seems no outlook for development of demand for light ash in the glass industry in the ASEAN. The sodium silicate industry generally uses dense ash, but light ash is used when dense ash is not available. The MSG makers similarly use dense ash, because of the relative ease of handling it provides. It is not possible for light ash to be used for STPP production. There are frequent instances, however, of the use of light ash by the detergent industry because of its lower price.

With regard to the percent of Na_2O content in soda ash, users make no special requests in connection with their use of the soda ash. As long as the price per unit component is constant, whether the component is present in a high concentration or low concentration does not present a problem regarding marketing. In fact, there are many plants where Kenyan natural ash has been used at least up until the present time.

Standards regarding the presence of impurities are strict when the soda ash is to be used to make MSG. The soda ash must meet requirements for food additives, with regard to such matters as the presence of heavy metals. Neither East European nor natural ash are suitable

Table II-4 DEMAND FOR SODA ASH BY USER INDUSTRIES, 1985 AND 1990

(000 tons)

	Sheet Glass	Bottle/Container Glass	Sodium Silicate	Others	Total
1985					
Thailand	28.3	75.7	13.3	2.3	119.6
Indonesia	21.6	93.0	7.7	2.3	124.6
Malaysia	15.1	27.0	6.6	4.8	53.5
The Philippines	10.2	67.8	8.1	23.0	109.1
Singapore	–	19.0	2.7	1.0	22.7
Total	75.2	282.5	38.4	33.4	429.5
(% of Total Demand)	(17.5)	(65.8)	(8.9)	(7.8)	(100.0)
1990					
Thailand	41.7	108.8	21.1	3.7	175.3
Indonesia	26.8	130.1	10.9	2.3	170.1
Malaysia	23.2	38.1	8.1	4.8	74.2
The Philippines	12.1	87.7	12.2	34.7	146.7
Singapore	–	22.0	3.2	1.1	26.3
Total	103.8	386.7	55.5	46.6	593.6
(% of Total Demand)	(17.5)	(65.3)	(9.4)	(7.8)	(100.0)

Sources: Tables AII-1, AII-10, AII-15, AII-19, and AII-22 in Annex-II.

for use in making MSG.

For other industries, the presence of impurities is not a problem. All of these other industries use soda ash from a number of sources, and there have not been any instances of production problems due to the presence of impurities. In the case of Thailand's sheet glass plant, however, Japanese synthetic ash has been used, and it will be necessary to conform to the standards of that ash. Even with regard to the fluorine present in Kenyan natural ash, no problem is encountered by any users except the MSG makers.

1-2 PRESENT CONDITIONS OF SODA ASH PURCHASING AND DISTRIBUTION SYSTEMS IN THE ASEAN REGION

1-2-1 Mode of Importation and Purchasing

In general, soda ash users import the product in accordance with their requirements, either through general importers or exporters' agents, in addition to which the general importers and export agents sometimes import the product on their own initiative, and then endeavor to sell it. There are also instances such as described below when importation is done by groups.

1. In the Philippines glass makers purchase soda ash through the Glass Manufacturers Association (GMA). There are two producers of sodium silicate in this country but because they also make glass, they obtain soda ash through the GMA.

2. In the case of the companies of the ACI Group which produce glass bottles and containers in joint-venture plants in various locations in the ASEAN region, use is made of centralized buying.

1-2-2 Transport Modes

The transport modes used for soda ash in the ASEAN countries are as follows.

(1) Philippines

All imports enter at Manila and barges are used to transport the soda ash from there to other ports. Lot size on the arriving vessels at Manila is about 7,000 t. All imports are in bulk and bagged in Manila when necessary. In some cases, the soda ash is transported in bulk from Manila to the plants where it is to be used, depending on the nature of storage facilities at the plants.

(2) Malaysia

Most soda ash users are located in the Kuala Lumpur area. A glassmaker, Malaya Glass, and a sodium silicate maker, Malaysian Acid Works, both having plants located in Johore, import their soda ash via Singapore. The other users obtain their shipments through Port Kelang, where there are bulk storage facilities from which shipments are made by truck. In the case of the KL Glass Co., there is a silo for bulk storage at the plant and shipment is made in bulk from the port in a closed truck. For other users, soda ash is bagged at Port Kelung for shipment. The import lot size is bout 5,000 t in the case of Kenya ash.

(3) Malaysia-Johore

The two companies in Johore which use soda ash obtain it from Singapore or through Johore port.

(4) Indonesia

Shipments enter at Jakarta (Tanjun Priok) and when bagging is required for shipment from the port of entry it is done there.

(5) Singapore

Singapore Glass receives bulk shipments; the Chemical Corporation of Singapore receives bagged shipments. Import lot size is about 7,000 t.

(6) Thailand

Shipments enter at Bangkok port, and shipment to users from that point is by truck or riverboat. The sheet glass plant has all shipments made in bags to prevent contamination of the soda ash by foreign matter. The glass bottle and container makers take either bulk or bagged shipments depending on the type of storage facility they have. In the case of product from Kenya, import lot size is about 15,000 t.

Contracts for soda ash for delivery to ASEAN countries are ordinarily C & F (or CIF). Frequently, however, large contracts are made on an FOB base in order for the buyers to enjoy any benefit from lower freight costs. Large contracts are commonly made on a 6-month to one-year long-term basis. Moreover, there are spot imports of soda ash from East Europe, Korea and elsewhere. Regarding overland transport from the port of entry to users' plants, where trucks are used, as in Malaysia and Indonesia, the importers arrange for truck transport at the expense of the buyers while where barges are used as in the Philippines, arrangements